ACTA RADIOLOGICA
EDITA PER SOCIETATES RADIOLOGICAS DANIÆ, FENNIÆ, HELVETIÆ, HOLLANDIÆ, NORVEGIÆ ET SUECIÆ

VOL. XXI FASC. 2 30 : IV 1940 N:o 120

HALF-AXIAL PROJECTION IN ACCENTUATED LORDOSIS FOR ROENTGEN STUDIES OF THE LUNGS[1]

by

Knut Lindblom

The roentgenologic method for the examination of the lungs has been considered by the casual observer as almost perfect. Experience shows, however, that this epithet is far from adequate. One pronounced deficiency is the difficulty in determining the nature of an observed process, at least from the etiologic point of view. Another inadequacy is often also encountered when there is a question of establishing the presence of a pathologic process and of studying the details in it, the reason being not only too slight a difference in the degree of absorption between the process itself and its surroundings, but also interfering projections of the bony and fleshy parts over the area in question. In addition, the position of a process observable on a frontal view is difficult to determine in a sagittal, when both lungs are involved and when the process is little marked and appears in a different way in the frontal and sagittal views.

The methods used to minimize these drawbacks are oblique projections, apex projections with the patient leaning forward (ALBERS-SCHÖNBERG, GÄBERT), separate, lateral views of the apex of each lung (THORELL, TORELLI, TWINING), axial projections (BARSONY and KOPPENSTEIN), and tomography or planigraphy. All of these have their advantages and disadvantages, which will not be treated in more detail here. It should simply be mentioned that their execution and results are such that they have not been included in routine examinations. The opposite is the case with the method to be described here, and which will be termed

[1] Submitted for publication Nov. 1, 1939.

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half-axial projection (eliminating »in accentuated lordosis», for the sake of convenience).

The term used here, half-axial projection of the lungs, is identical with the German »Kreuzhohlstellung», and has previously been described in the study of inter-lobar fissures (FLEISCHNER, and others), and in the study of the lungs (FERRARI). However, as this type of projection seems to have been very little used hitherto, and as I have found it to be not only of great assistance in the examination of the apical portion of the lungs, but also so simple that it could easily be adopted as part of the routine examination, I have considered the publication of a paper on it to be of interest.

Half-axial position. (Fig. 1.) When in a vertical position, the patient stands or sits, leaning backward, with the upper portion of the interscapular region towards the film, the head bent forward, and the abdomen and shoulders thrust forward; the direction of radiation is horizontal. (Fig. 1.) When the patient is in a horizontal position, the film is placed under the region of the shoulders at an angle of from 30—45 degrees to the table, the head is bent forward and the shoulders, if possible, thrust forward; the direction of radiation is at an angle of from 30—45 degrees from below. The exposure is the same as for the frontal view but with an increase of the mAs by about 50 %, or an increase of the voltage by about 10 kV.

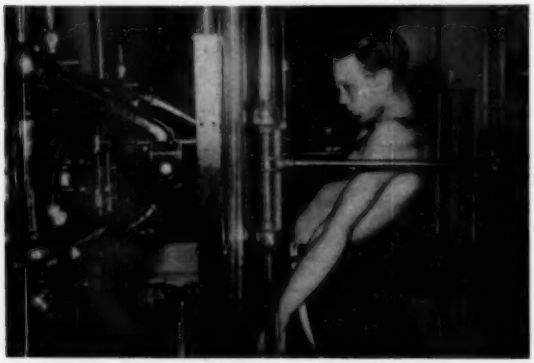
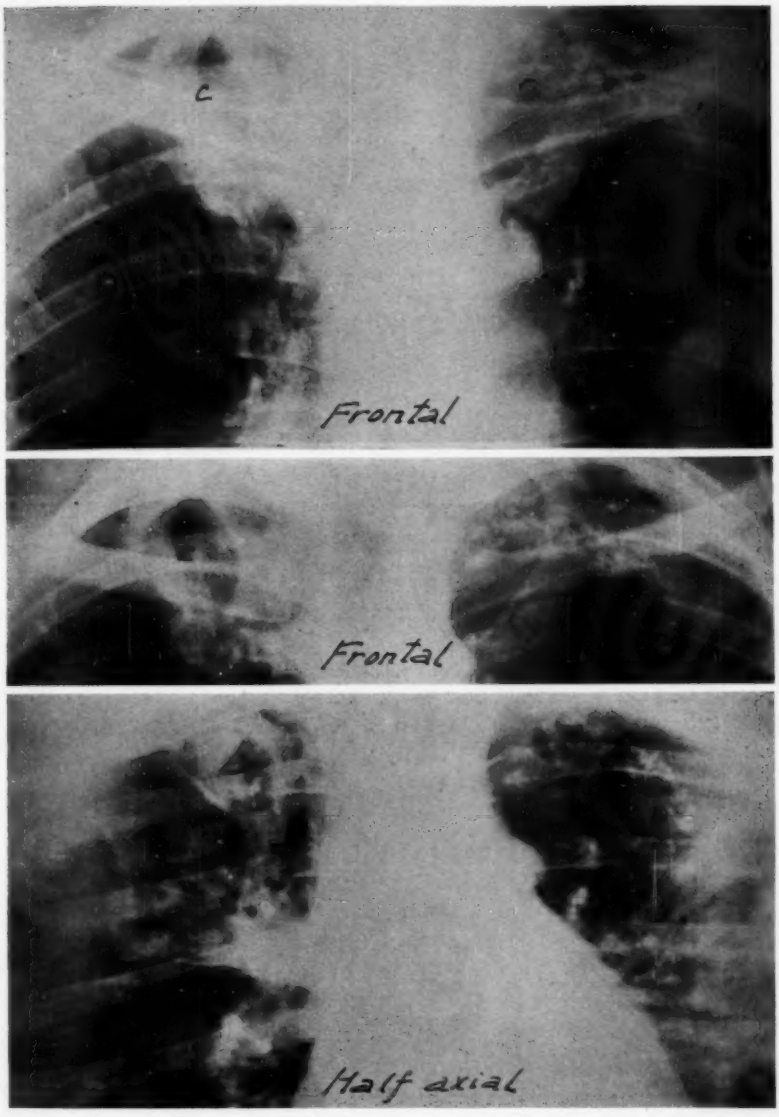


Fig. 1. Photograph of patient in half-axial position.

The half-axial view in normal cases. The upper lobes and the middle lobe are projected above the lower lobes and the principal fissures generally appear. The ribs run horizontally and the clavicles lie above the apexes of the lungs. The contrast between the pulmonary tissue and that of the surrounding area, owing to the greater depth of the respective layers, is stronger than in the frontal view. The apex of the heart is visible to a greater extent than in the frontal view. The lower lobes of the lungs are largely covered by subphrenic fleshy parts and only appear with a further increase in the exposure. Large mammae can cause an underexposure also in the areas above the diaphragm.



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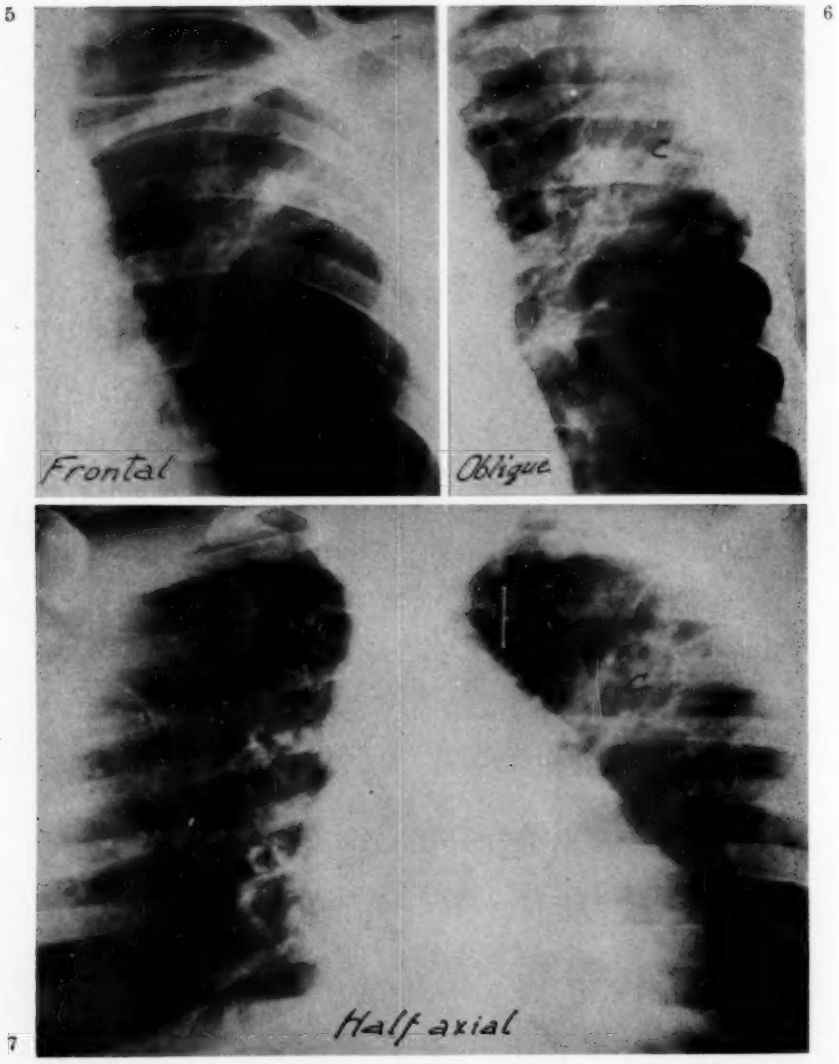
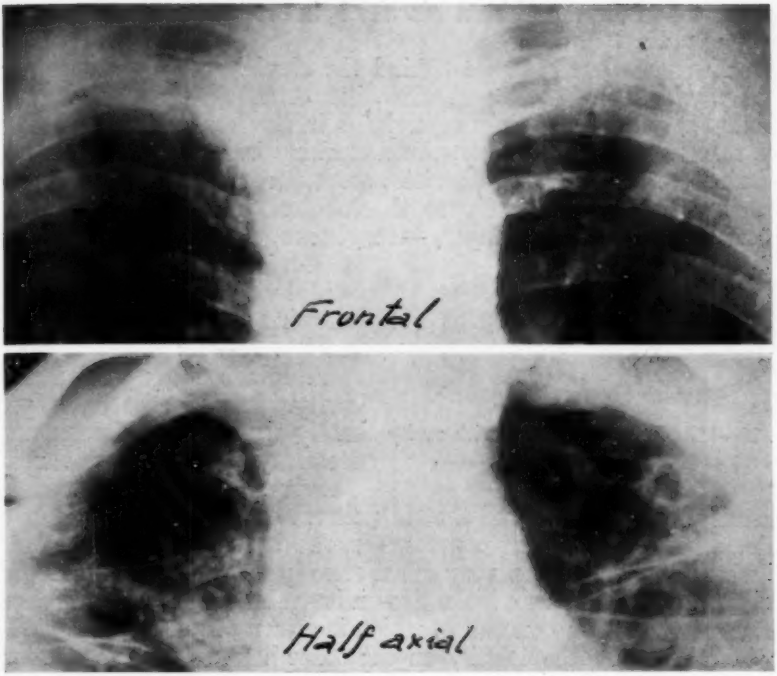
Figs. 2—4. Frontal and half-axial roentgenograms of a case of bilateral upper lobe tuberculosis. Compare visibility of cavity (c) and process in right lung.



Figs. 5—7. Frontal, oblique, and half-axial roentgenograms of a case of left upper lobe tuberculosis. Compare visibility of cavity (c).



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Figs. 8—9. Frontal and half-axial roentgenograms of a case of upper lobe tuberculosis. Note visibility of cavities in half-axial view.

The half-axial view in pathologic cases. (Figs. 2—11.) In this paper, the subject of the bases of the lungs has not been treated, the chief attention being given to that of the apical portions. As regards details, readers are referred to the comparison between the frontal, oblique and half-axial views reproduced.

As a rule, densifications show more distinctly in the half-axial than in the frontal views, not only because of the absence of disturbing overprojections from the clavicles, but also because the contrast is greater than in the frontal view, even when the kV instead of the mAs are increased. Densifications in the upper and middle lobes lie above those in the lower lobes.

The heightened contrast is explained by the increased summation of densifications. A pathologic process, when developing, generally follows the bronchia, and the most usual localisation of tuberculosis

is in the area of the dorsal bronchia which, in the half-axial view, are seen in a longitudinal direction.

Cavities, whether they lie behind the clavicles or elsewhere in the apical portions, in the frontal view, are often clearly marked in the half-axial view but indistinct or invisible in the frontal view. There are three reasons for this. Firstly, the disturbing influence of the clavicles is eliminated. Secondly, the cavities are often oval, with their greatest length running longitudinally to the lobules, and for this reason the thickness of the pathologic layer, — and hence, the contrast, — is greater in the half-axial than in the frontal view. Thirdly, there is the following explanation, illustrated in Figs. 10—11:

Figs. 10—11. Sketches of lobule with cavity seen in profile, and axial to lobule.

A lobule is expanded by a cavity. In most cases, a proximally situated bronchostenosis is necessary for the appearance of a cavity. The area surrounding the cavity forms a thin wall that is uniform except at the apex of the lobule, where the causative process in the bronchial wall is situated, and where a densification very often already exists. When seen from the side, the whole picture looks like an irregular or indistinct ring, one-quarter of the outer contour of which is drawn out to a point. When seen lengthwise to the lobule, on the other hand, the ring is uniform. The uniform, double-contoured cavity is undoubtedly the more easily observable.

It is worth noting that tomography has scored successes especially as regards cavities in the apical portions of the lungs. A tomograph has only once been at my disposal, but it gave no further information. In the other cases no comparative examination was possible. There seems, however, to be justification for assuming that the contribution provided by half-axial projection definitely lessens the indications for tomography.

SUMMARY

Half-axial projection in accentuated lordosis, = »Kreuzhohlstellung», is an easily achieved and very valuable assistance in the study of the upper portions of the lungs, not only for establishing the presence of a pathologic process, but also for the visualization of cavities. This type of projection should be adopted as part of routine examinations.

ZUSAMMENFASSUNG

Halbaxiale Projektion bei stark ausgesprochener Lordose »Kreuzhohlstellung« ist eine leicht zu erlangende und sehr wertvolle Hilfe beim Studium der oberen Lungenregionen, nicht nur für die Feststellung des Vorhandenseins eines pathologischen Prozesses, sondern auch für die Sichtbarmachung von Kavernen. Dieser Projektionstyp sollte zu einem regelmässigen Bestandteil des allgemeinen Untersuchungsganges werden.

RÉSUMÉ

La projection hémiaxiale dans la lordose accentuée (»Kreuzhohlstellung«) représente une aide très appréciable et facilement obtenue dans l'examen des parties supérieures des poumons pas seulement pour établir la présence d'un foyer pathologique, mais aussi pour rendre visibles les cavités. Ce mode de projection devrait être partie intégrante de l'examen routinier.

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ON BONE DEFECTS IN TERMINAL PHALANGES[1]

by

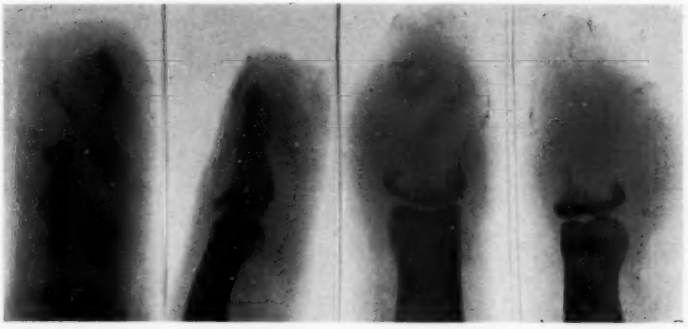
Nils Frostberg

In many cases of morbid changes in the skeletal system the roentgen picture permits of a fairly specialised diagnosis. Now and then, however, changes are encountered which give rise to great difficulties in the differential diagnosis. In some cases we may then be guided by the history and clinical examination. Off and on, however, it is only the pathoanatomical examination that reveals the true nature of the changes. In our discussions on the differential diagnosis regard is had, not only to the appearance of the changes but also to the question whether the localisation is the usual one for this or that disease.

In perusal of the literature we find, as regards some diseases, very scanty reference to skeletal changes in the terminal phalanges. The author who has looked up the case records of the Roentgen Dep. of Maria Hospital wishes, on the basis of these cases as well as two further cases from »Vanföreanstalten» in Stockholm and the Roentgen Dep. of Kalmar Hospital, to make a contribution to the already existing clinical material.

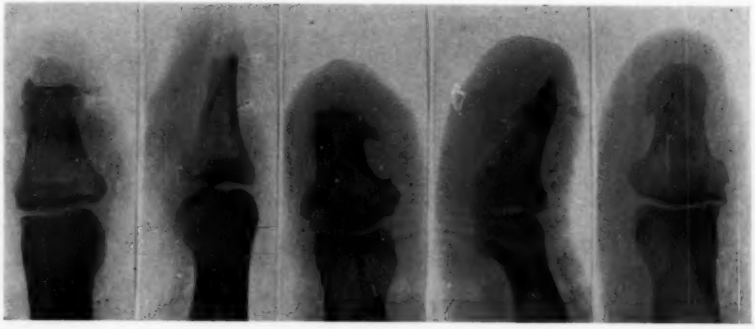
The large majority of cases that come up for roentgen examination of some condition in the terminal phalanges show *fractures* or *osteitis*. The former group may be disregarded here since as a rule it causes no diagnostic difficulties. Of the latter group a few cases have been included, more in order to illustrate that certain similarities with other diseases may exist and where really the history has caused one only to consider osteitis as a diagnosis. Thus, for example, cases 1 and 2 (Fig. 1) are clinically typical osteitis, yet there is nothing in the radiograph against the possibility of some other destructive process, e. g. tumour. Cases 3 and 4 (Fig. 2) are also osteitis but of a different type. The changes have mainly affected the unguinal process of the terminal phalanges. In the former case the clinical picture was fairly clear but in the latter the

[1] Submitted for publication Nov. 22, 1939.



a b c d

Fig. 1. Osteitis.



a b c d e

Fig. 2. Osteitis.
e = healthy side to c and d.

possibility of some mutilating process of vasomotor or trophoneurotic origin was also discussed.

This was the case of a woman, aged 78 (Fig. 2, c, d, e) who for the past 10 years had had some trouble with her left thumb, this now and again swelling up with the formation of purulent blisters. On account of the symptoms recurring an incision was finally made and the phalanx nipped off. *Patho-anat. ex.* showed »well-marked acute haemorrhagic and purulent inflammation localised to corium and subcutaneous tissue. The histological appearance does not favour a process of specific nature». (WAHLGREN.)

In the *chronic form of polyarthritis*, primary and secondary, we shall find sooner or later, besides reduction of cartilage, also deformities with erosions of the joint surfaces. The latter may become very extensive with destruction of the whole tip of the phalanx. In typical rheumatoid

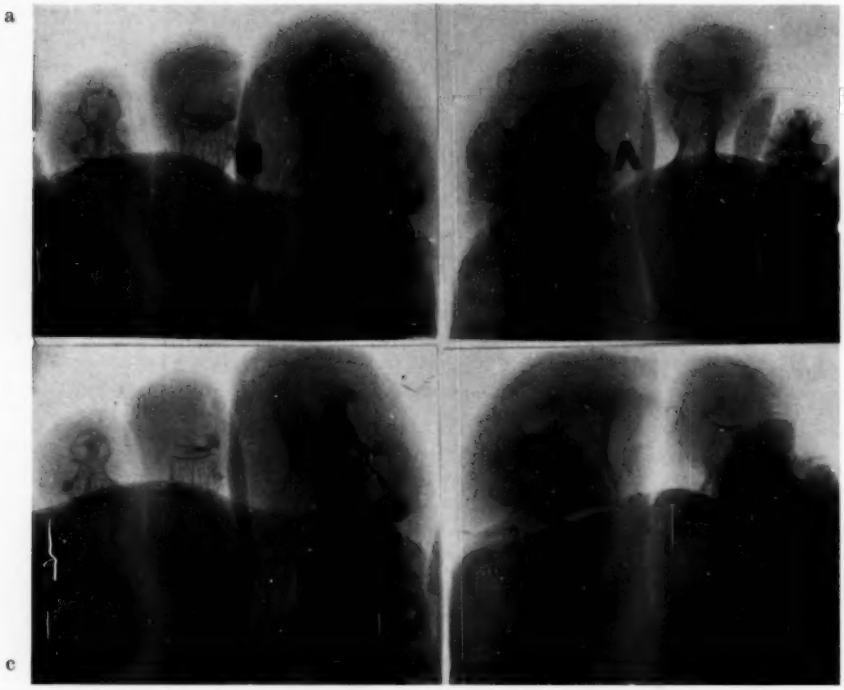


Fig. 3. Benign lymphogranulomatosis.
a and b = 7/12 1933.
c and d = 14/4 1934.

arthritis a mutilating form may even occur, leading to wellmarked shortening of fingers and toes. As these changes occur in several joints and neighbouring phalangeal ends the differential diagnosis offers no greater difficulties.

Many of the *specific inflammatory changes* may be localised to the terminal phalanges. In this country *tuberculosis* is perhaps the most common condition so far the other phalanges and metacarpal bones are concerned. All the phalanges, however, may be the seat of spina ventosa with its bottle-shaped enlargement of the phalanges on account of absorption from within through tuberculous granulation tissue and periostal depositing from without. The author is not aware whether phalangeal tuberculosis, as occurring in elderly people and which presents quite a different picture, can also be located in the extreme phalanges. The 3 cases described by STENSTRÖM showed no changes in the terminal pha-

nges. In *syphilis* we also find an appearance resembling spina ventosa, phalangitis luetica. At the Roentgen Department of Maria Hospital we have not come across any cases of tuberculosis or lues in the terminal phalanges.

Regarding *leprosy* MURDOCK and HUTTER would seem to possess the largest roentgenological material. The bony system of altogether 1 000 cases have been radiographed. The changes are found to commence in the terminal phalanges and then either as tiny defects, »nicks», in the unguinal process or as cystic cavitations reminding of the picture in the so-called »osteitis tuberculosa multiplex cystica» (i. e. benign lymphogranulomatosis). The above minor defects of the terminal phalanges as well as pathologically enlarged foramina nutritia (on account of leprous vascular changes) justify the radiologist to suspect leprosy. We have had no opportunity of examining any case of leprosy. As to the differential diagnosis from leprosy special interest is attached to Raynaud's disease and scleroderma and to some extent benign lymphogranulomatosis (Morbus Schaumann).

Benign lymphogranulomatosis is a generalised disease with foci of granulation in most organs, e. g. the bone marrow. Such foci need not result in defects of the bone. Cases exist where skeleton shows a perfectly normal appearance on the radiograph or where there is only evidence of some diffuse osteoporosis. In advanced cases we find major or minor defects, particularly in the phalanges. Even an entire phalanx may be destroyed. The myeloid changes may reach beyond the bony tissue and give rise to spina-ventosa-like enlargements of fingers and toes.

Fig. 3 shows a case of that nature which we had the opportunity of seeing a couple of times at Maria Hospital. It is the case of a man, aged 41 (Bes. i. 384) who had previously been well. No tuberculosis in the family. Now ill since 1930 with generalised fatigue, coryza and a stuffy nose and increasing thirst. Operation for polypi in the nose resulted in only short-lived improvement; later glands on both sides of the neck. Further, injected infiltrations of the nose, especially on the nasal wings. The patient was under treatment at a sanatorium for his »glands». No pulmonary changes are supposed to have been present at that time. As his condition got worse and symptoms of diabetes insipidus supervened the patient was admitted to Maria Hospital, medical section, in 1933 where he was treated for two periods and died on Dec. 20 1934. Regarding hands and feet the case record includes the following notes: ». . . mild deformity with generalised swelling and reddening of bone and soft tissues of 2nd toes, skin over the 2nd toe on the right and left side somewhat cracked. Right ring finger likewise swollen, particularly over the middle phalanx.» During the subsequent course deformative changes were observed on several toes of both sides. The right ring finger swelled up still more and the fifth finger on the left side also showed a swelling. On *Rtg.* examination Dec. 7 1933 (Fig. 3 a and b) of both feet the terminal phalanges were found the seat of more or less marked vesicular bone destructions. In addition, on the medial aspect of the 1st phalanx of the right big toe there was a superficial destruction of the cortex calis. Examination of the bones of the hands revealed destructive processes of some of the middle and 1st phalanges; terminal phalanges, however, were intact.

Fig. 4. RAYNAUD's disease.

After 4 and 12 months respectively further pictures were taken (Fig. 3 c and d) which showed progression of the bony changes. It is noteworthy that in the feet roentgenological changes were almost confined to the terminal phalanges. The lungs showed a picture well in accord with lymphogranulomatosis benigna. Autopsy showed typical evidence of this disease.

In 1935 TILLGREN gave an account of the same patient in reference to his diabetes insipidus which proved to be caused by benign lymphogranulomatosis of the hypophysis.

As already mentioned RAYNAUD's *disease*, as a result of vasomotor disturbances, may present a clinical picture reminding of leprosy. We have seen a case of this nature at Maria Hospital.

It was the case of a saw-mill labourer, aged 31 (Fig. 4, Pe. i. 96), who was under treatment in the med. and sur. section in 1925. He had earlier been well and there was nothing of interest in the family history. About $1^1/_2$ months before admission to hospital he began to notice the toes of his right foot becoming cold and numb. Gradually the whole foot become cold. Finally the pains grew severe enough to prevent him from sleeping and only hot foot-baths gave him temporary relief. On admission there were no pulsations in the right foot, it was cold and pale with a tinge of blue. Blood-pressure 180/100. Knee-jerks livlier on right side than the left. Other reflexes were normal. Sensibility possibly somewhat dulled round the inner malleolus. Nervous system otherwise normal. Wassermann reaction negative. After about 3 weeks a small wound arose spontaneously on the lateral-volar aspect of the 4th toe; it grew to the size of a pea and refused to heal. *Rtg. ex.* a fortnight later showed on the terminal phalanges of the 2nd and 3rd toes distinct destructions clearly demarcated by sharp lines. The 4th and 5th toes were obscured by ointment dressing. Beyond this there were no skeletal changes. The patient improved after sympathectomy (KEY) and was discharged from hospital.

This disease was so comprehensively described by RAYNAUD in 1862 as to leave very little to be added since then. In 1901 BECK of Chicago submitted the first reports on bony changes in R:s disease. In advanced cases such changes are even clinically obvious but cases exist without any necrosis of soft tissue but with bone destruction. In 1927 BORAK gave an account of 12 patients with R:s disease. In all the cases with bony changes there were also dystrophic skin disturbances and unguinal changes but cases also existed with changes of the skin but where the bone was intact. Those cases which showed an intact skin but characteristic vasomotor symptoms proved to have no bony changes. It is

lear therefore that in the case of bony changes being present in R:s isease it is a question of a definite stage; BORAK also divides the disease to three stages. It is only through secondary infection that periosteal epositing and gangrene can arise. Such changes have also been de- ribed by certain authors, e. g. ALBERS-SCHÖNBERG and PHLEBS, but BORAK's opinion they are not part of a true R:s disease. In difference the skin defects skeletal changes arising in R:s disease show no retro- ression because such changes may arise in skeletal parts with the skin tact as is evident from the case above described. As a rule the bone anges engage the unguinal process of the terminal phalanges, seldom e base or the second phalanx. It is exclusively a matter of loss of sub- ance with absorption of necrotic bone. In genuine cases sequestration reactive changes from the surroundings do not occur.

The normal and sharply defined curved line of demarcation of the unguinal process shows, either at the apex or nearer the side, shallower or deeper defects. In advanced cases the curved line is seen to be obliterated, a straight demarcating line taking its place, the unguinal process being entirely absorbed. In the case of the absorption starting in the middle of the phalanx we get only the picture of a large hole (Knochenlücken). If the defects are located near the joint they are well separated from this although secondary changes may arise there. Primary arthropathies do not seem to occur in RAYNAUD's disease. The question arises whether the bone changes may be the result of »Knocheninfarkten». BORAK discusses the possibly endogenous origin of RAYNAUD's disease and shows cases of syringomyelia and tabes which are very much alike.

When the skin changes in *scleroderma* affect the fingers we speak of *sclerodactylia*. The etiology of this condition is obscure but on some hands it is considered a question of angiotrophoneurosis, either of the peripheral or the central nervous system. Many authors, e. g. KORNBLUM and PAUL MC. ILLHENNY, maintain that, purely roentgenologically, it is impossible to differentiate leprosy, RAYNAUD's disease, scleroderma and psoriasis from one another. Regarding sclerodactylia EIDECKEN has made an interesting observation. The terminal phalanges showed signs of atrophy and absorption, conveying the impression of amputation, but in 2 of his 3 cases small calcium-dense shadows were seen in the soft parts of the finger-tips while the third case showed increased calcification in the end of the phalanx. This would not happen in any of the other cases mentioned above. Appearances of that nature were described by SCHOLEFIELD and WEBERT in 1911 and by OLSON in 1917. The latter author has collected 8 cases from the literature. In his Lehrbuch der Röntgendiagnostik and in Rtg. praxis 1939 SCHINZ has reproduced beautiful pictures of a case of that nature which at first showed the above mentioned changes of osteoporosis and osteolysis of the terminal phalanges.

Radiographs 7 years later showed, besides progression of these changes calcium deposits in the soft parts. Chemically these deposits consis of calcium carbonate and calcium phosphate.

Bone changes in *psoriasis* have been described, among others, b STRÖM and BÜSCHER. The latter's report is dealing with a case of ar thropathia psoriatica. Extensive destructions are seen in the bon here round the distal interphalangeal articulations. The cartilage i also seen to be reduced. The unguinal processes of the terminal phalan ges seem, however, to be less affected here. The case published by STRÖ shows defects close to the joints as well as on the unguinal processes.

As mentioned above *syringomyelia* and *tabes* may present simila changes. From Fig. 2 it is evident that changes of the above type ca also be present in osteitis, typical both in regard to history and clinica course. The view is frequently expressed that psoriasis should be groupe with lipoidosis to which HAND-SCHÜLLER-CHRISTIAN's and GAUCHER' diseases also belong. While changes in the bones of hands and feet ar absent in the former disease, such are often found in GAUCHER's disease. In the bony form phalanges and the lower jaw are seats of predilection. SCHINZ is reproducing a plate as well as pictures of such bony changes.

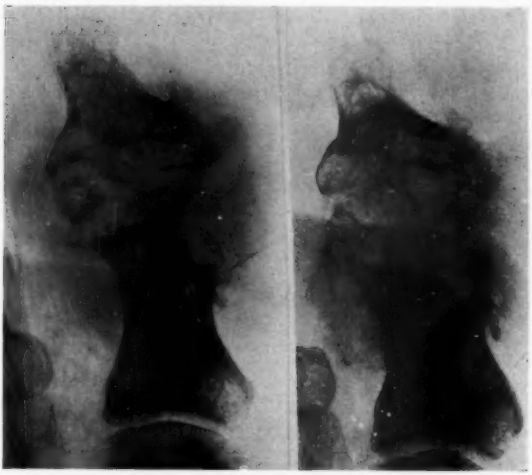
Gout off and on produces changes in the terminal phalanges. The picture is as a rule characteristic, with vesicular rarefactions in the adjacency of the joints. I shall only show the picture of one case of that nature (Fig. 5. Pe. gikt 7), a man, aged 50, with typical complaints for the past 15 years and uric acid values of up to 9 mgm. %. Obvious aggravation during the last 12 months.

Tumours and tumor-like formations in the skeleton itself or the soft parts give rise to defects of the bone. So far these cases are concerned our clinical material is too limited to permit of any conclusions as to what is typical for this or that tumour.

We have had two cases of *post-traumatic epithelial cysts* giving rise to defects in the bone of the terminal phalanges.

The first case (Fig. 6, a and b. Ms. 28) was that of a married woman, aged 24, who at the age of 17 had sustained some machine injury to her left middle finger. Since then been well till about 20 days before the day of examination when she began being troubled with ache in the finger. Consulted the surgical out-patients here. She was then very tender over the terminal phalanx which was felt to be tense. No redness. Moderate swelling at the radial dorsal part of the end phalanx. No signs of lymphadenitis or lymphangitis. *Rtg. ex.* showed »on the radial aspect of the base of the end phalanx a sharply defined rarefied area the size of half a pea. No adjacent sclerosis. Calcium contents normal. It is probably a question of a bone cyst ...» *Operation.* — Removal of cyst with atheromatous contents. *P. A. D.* Epithelial cyst (WILTON).

The second case (Fig. 6 c and d. Ms. 33) was that of a married woman, aged 34, who 2 years earlier had jammed her right index finger. It was entered in the case record at the time that the nail-bed had a blue-black discoloration and that there was a super



a b

Fig. 5. Gout.
a = $^{23}/_{1}$ 1932.
b = $^{13}/_{1}$ 1933.

ficial abrasion of the skin on the dorsal aspect proximally of the nail. She is now again consulting the surgical out-patients because of a steel splinter she got into the tip of her right index finger about 1 month ago. She does not know whether she got the splinter out properly. The right index finger was swollen, scarcely flushed, moderately tender on pressure round the whole tip of the finger. No signs of arthritis or tendovaginitis. *Rtg. ex.* »In the distal part of the end phalanx there is a defect stamped out right through the bone and of an appearance as to suggest its being caused by the pressure of some tumour. There is no shadow of any dense foreign body . . .» *Op.* (KEY). . . . The tumour was non-vascular, white in colour and well localised in a hollow of the phalanx . . .» *P. A. D.* The structure removed is partly made up of a traumatic epithelial cyst, partly of granulation tissue beyond the cyst, mainly consisting of epithelioid cells and giant cells of some foreign body containing numerous horn splinters. (WAHLGREN.)

In both cases we find roentgenological evidence of well stamped out defects raising suspicion of pressure from some foreign formation. The last case was to some extent complicated by subsequent trauma with reaction from some foreign body. A case remarkably similar in appearance was described by HARRIS in 1930. In 1925 BURROWS recorded a case with two vacuoles in the phalanx of one of the thumbs, found to be caused by an epidermoid cyst. Multiple defects may thus arise.

Fig. 7 shows a destructive process in the left ring finger. It is the case of an elderly woman under treatment at the Kalmar Hospital (Rtg. no. 4522/38) from $^{12}/_{9}$ till $^{15}/_{10}$ 1938 under the diagnosis: chronic myocarditis, incomp. cord. levis, chronic polyarthritis,

a b c d

Fig. 6. Epithelial cysts.

Fig. 7. ? Epithelial cyst, ? Enchondroma.

mental debility. She showed changes of chronic polyarthritis, clinically and roentgenologically, in both hands. The end phalanx of the left ringfinger was enlarged and somewhat crooked, besides being flexed in the top joint. The skin was somewhat tense over the diffuse swelling. The patient is unaware of any injury to her fingers but she says her left ring finger has always looked like it does now. As she is rather debilitated, however, she does not seem to be quite clear about things. *Rtg. ex.* (WOLKE). »Showed a vesicular destruction in the radial portion of the end phalanx of the left ring finger . . .» Etiology unknown. *P. A. D.* was never obtained. There is however reason to suspect an epithelial cyst although the appearance also bears some likeness with Fig. 10 c, an echondroma.[1]

Glomus tumours present to some extent similar appearances. Of cases of that nature resulting in defects of the end phalanges we have seen 3 cases.

The first case (Fig. 8 a, b, c. M. n. 2743) was that of a shop assistant, aged 23, who for 4 years had been tender under the nail of her left ring finger, in her own view due to a cut on the volar aspect of the terminal phalanx. There has lately been some aching up the finger, especially on this being cold. Marked tenderness on pressure on the nail; a blue-red spot, the size of a pin-head, can then be noticed in the nail-bed. *Rtg. ex.* »In the extreme end of the distal phalanx there is seen a rarefaction in the bone, in size less than that of a pin-head. It may possibly be due to pressure erosion.» *Op.* Incision and excision. *P. A. D.* The specimen received consists of minimal bits of tumour tissue built up of fairly small cells, very much alike epithelial cells, between which there is a sparing amount of collagenous matrix. In some places pathological vessels can be seen. The histological picture is typical for a so-called glomus tumour (WAHLGREN).

[1] Under the title »Zur Frage der Knochenrückbildung» DITTRICH describes a case with stamped out defects in the bones of the phalanges of the 2nd, 4th and 5th fingers of the right hand. It was the case of a man, aged 29, who nine months earlier had sustained some injury to the skull (nothing mentioned about the fingers). The nails were elevated and *Rtg.* revealed one-roomed well localised defects in the distal halves of the end phalanges. P. A. D. not obtained. The origin of these changes was discussed in detail and the author suggests the possibility of *inter alia* a mutilating form of osteitis. In view of the above pictures and history epithelial cysts would also seem to merit discussion.

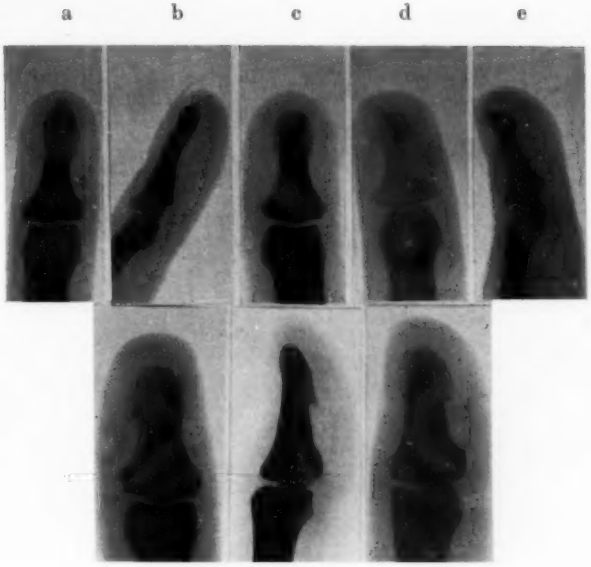


Fig. 8. Glomus tumours.
c = healthy side to a and b.
h = healthy side to f and g.

The second case (Fig. 8 d, e. Vanföreanstalten 619/37) is that of a woman, aged 22, who in 1931 had an operation for a tumour under the nail of her left middle finger. She never got quite well. There is still aching and tenderness. No fever or suppuration. The nail is somewhat raised. At the base there is a blue-red discoloration and also tenderness. *Rtg. ex.* (KNUTSSON). In the radial part of the extreme phalanx of the left middle finger there is a curved defect having the character of pressure atrophy. *P. A. D.* (WAHLGREN). The extirpated growth is a so-called glomus tumour (MASSON).

The third case (Fig. 8 f, g, h. Ms. 32) is that of a shop assistant, aged 29, who periodically for several years had been troubled with aching in the top phalanx of the right thumb. The aching had no reference to work or the weather. It never gave her so much trouble as to prevent her from working. In her own opinion she thought that, being much occupied besides with other kinds of work, with fixing in drawing pins this might have had something to do with the start of the trouble. Both the end phalanges of the thumbs were long and narrow and flattened out volarly, the right one more than the left. No tenderness on pressure. *Rtg. ex.* (ÅKERLUND). »Small non-typical rarefaction in the distal portion of the end phalanx of the right thumb. In a lateral picture this rarefaction proves to belong to the volar region and have the character of a small hollowed out pressure erosion which seems to presuppose the presence of some small foreign formation in the soft tissues. The roentgen examination affords no direct information as to the character of this structure in the soft tissues. In a few cases earlier observed it was a

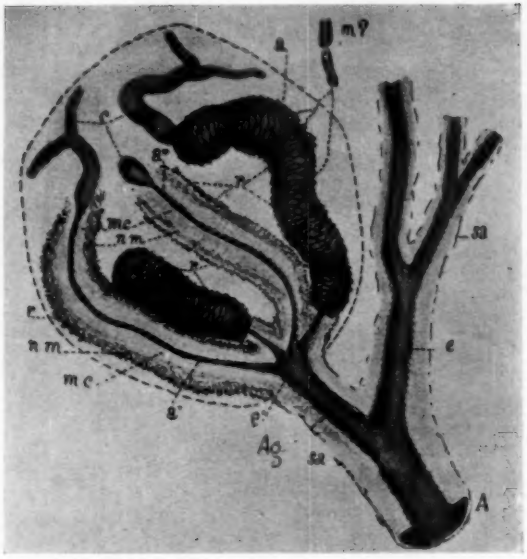


Fig. 9. Diagrammatic picture of glomus tumour (after BARRÉ and MASSON).

question of glomus tumour but it may be a formation of different character (traumatic epithelial cyst).» *Op.* (STRÖMBÄCK) and *P. A. D.* (REUTERVALL). »Benign glomus tumour.»

In 1924 BARRÉ and MASSON described two cases of subungual tumours of fingers. In one of them the symptoms had arisen after some trauma, in the other one without any known cause. The first patient, a girl, aged 18, suffered very severe pains which spread over the whole half of the body. She got relief by dipping the finger in cold water. In the other case who reacted to things like damp cold the symptoms were relieved by warmth. In both cases there was a blue-violet tumour under the nail which was elevated. After removal of the tumours the pains disappeared. Anatomically these tumours were strangely built with an afferent artery and several efferent channels opening into an efferent vein. The structure of the channels was very peculiar. Innermost there was an endothelial tube round which smooth muscular fibres were arranged; these were more or less transformed into cells, resembling epithelium. A noteworthy circumstance was the abundant presence of non-myelinised nerve fibres (Fig. 9). The authors assumed that the glomus tumours served to regulate the blood-stream. The pain would be explained by the position between two solid planes, the phalanx and

ıe nail. The tumour was known before MASSON but went under a dif- rent name. It occurs as a rule under the nail but is also found elsewhere the skin of the extremities and in the coccygeal region. In 1937 BERG- RAND published two cases of multiple glomus tumours, a much more usual form. In none of these cases was the tumour located subun- inally. One of them was entirely located in the bone, an observation t earlier made.

The seat of predilection of *enchondroma* is the diaphyses of the ort bones, thus phalanges, metacarpal and metatarsal bones. GE- HIKTER and COPELAND have got a series of 71 cases of which 50 were ated in the above mentioned bones. Nor is it unusual to find such nours in ribs, sternum and the spinal column. Exceptionally they y be encountered in the long bones. As a rule some defect is seen he central portion of the bone, the cortex is swollen and thin and often seat of fractures. It happens that the tumour is only discovered in junction with a fracture. Roentgenologically it may be impossible to differentiate between enchondroma, cyst, benign solitary giant-cell tumour and myxoma. In the opinion of GESCHIKTER and COPELAND bone cysts and giant-cell tumours are more commonly found in meta- carpal and metatarsal bones than in phalanges. The multiple form of bone chondromatosis is often localised to metacarpal bones and phalanges. It is often combined with veins aneurysmatically dilated and phle- boliths. HULTÉN and LOVÉN have described a man, aged 27, who presented not only typical chondromata in skeletal parts (mostly right hand and foot where terminal phalanges were also the seat of changes) but also haemangiomata of soft parts. The latter gave rise to shadows resembling phleboliths and if they were lying close to the bone this showed a cuplike hollowing.

Of chondroma of terminal phalanges we have seen two cases at Maria Hospital.

The first case (Fig. 10 a and b. Ms. 6 a) was that of a woman, aged 28, who 11 years earlier had crushed her right thumb while skiing. A couple of years later a tumour began to grow on the dorsal side of the metacarpo-phalangeal joint. A little later another tumour developed roughly on the middle of the outer phalanx; this has grown gradually and more rapidly during the past twelve months. Cond. on adm. — On the dorsal side of the proximal end of the basal phalanx a tumour, the size of half a walnut. Consistence hard. In addition there is a somewhat larger tumour of the same kind on the distal phalanx between the root of the nail and the joint. *Rtg. ex.* showed on the volar aspect of the end phalanx of the tuhmb, corresponding to the swelling of the soft parts, a small superficial destruction of the phalanx. On the dorsal region of the basal phalanx there is a couple of rounded and well localised destructions. Calcifications were present in the bulging soft parts, more pointed in shape at the end phalanx, more cup-shaped at the basal phalanx. In addition there is also a minor change in the metacarpal bone. *P. A. D.* Chondroma (all the tumours), with cells of somewhat varying abundancy in the different tumours but no signs of sarcoma (HEDRÉN).

The second case (Fig. 10 c and d. Ms. 21) was that of a female clerk, aged 29, wh for at least 2 years had had a tumour of her right thumb which latterly had rapid grown in size. At the joint between the first and second phalanges there was a tumo projecting ulnarly, more than that of a pea in size and of firm consistency. *Rtg.* e showed within the outer phalanx a cystic destruction of the bone extending with the middle and ulnar parts of the base. It is not only a question of destruction of the bo but also of a deformity of the phalanx in that its base is prolonged toward the ulnar si for nearly half a centimetre, in addition to its base also being swollen on the volar sic It would seem, therefore, that we are dealing here with an expansively growing formati leading to vesicular bulging of the bone. On the volar and ulnar sides of the new form tion a complete bony shell is lacking ... The morbid changes were assumed of beni character and chondroma was considered the most likely. *P. A. D.* Enchondroma most probably benign nature (WAHLGREN).

Other kinds of bone tumours of phalanges are not included in th clinical material from the Roentgen Department of Maria Hospita The possible presence of such formations has already been mentione in the discussion on enchondroma. According to GESCHIKTER an COPELAND secondary deposits of cancer and multiple myelomata practically never reach terminal phalanges, no matter how widespread the change may be in other parts of the skeleton. Yet we find BRAILSFORD reproducing a picture with several foci of destruction in the phalanges caused by *metastatic cancer* where also the terminal phalanx is affected. He says that as a rule other symptoms have settled the diagnosis but that no primary tumour has chanced to be suspected or observed. In PLATT's opinion osteogenous sarcoma and secondary cancer are very rarely found in the bones of the hand and are unknown in the phalanges. The so-called spindle-cell variant of giant-cell tumours is most common in the small bones of the hand and foot besides in flat bones and vertebrae. GESCHIKTER and COPELAND have included a picture of such a tumour in their »Tumours of bone».

Finally an account will be given of two cases of *tumours emanating from soft parts* and causing defects of the phalanges, especially the terminal phalanx.

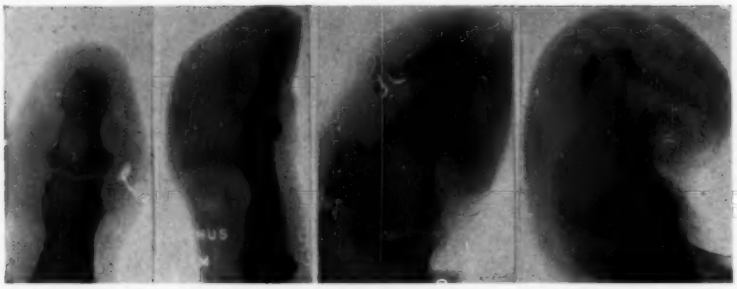
The first case (Fig. 11 a and b. Ms. 22) was that of a woman, aged 35, who was under treatment at the Roentgen Department for peritendinitis calcificans of the right deltoid region. On examination was found a swelling of the volar aspect of the third phalanx of the left index finger. According to the patient's statement she had had this for 10 years. The tumour could be moved freely on the phalanx. Its consistence caused one to suspect chondroma. The radiograph revealed a homogeneous soft shadow, well demarcated against surrounding structures, and the size of a nut. On the volar side of the outer phalanx there is a deep pit-like defect, well localised and with unbroken outlines. The defect has in all respects the character of a pressure atrophy. *P. A. D.* showed a *benign giant-cell tumour originating from the tendon sheath.*

The second case (Fig. 11 c, d. Pe. s. 16) was that of a labourer, aged 33, who 14 years earlier had been under treatment in hospital under the diagnosis: Distorsio ge dx. c. haemarthrosis + Unguis incarn. hallux sin. inf.. Radical operation by KÖRNIC's

Fig. 10. Chondroma.

method was performed. Was then free from symptoms till about twelve months ago when he noticed the nail of his left big toe beginning to bulge. No pains. The nail, of ordinary size, showed well-marked dorsal bulging; it is spanning over a subungual formation, almost the size of a walnut, and felt not to be as hard as bone. *Rtg. ex.* revealed a homogeneous softpart tumour quite the size of a grape and elevating the nail. In the bone can be seen one or two spikes of minor size at the boundary of the tumour as well as a few irregular spots of erosion. The changes in the outer phalanx may be considered as secondary changes to the tumour. *P. A. D.* The tumour specimen examined shows the picture of a *fibromyoma* without any greater cell polymorphism in the tumorous tissue. Purely histologically, therefore, this does not show any sign of being of malignant nature; the specimen to hand, however, does not permit us to study its relationship to surrounding tissues wherefore it must be left an open question whether it grows in an infiltrative manner or not. These tumours, however, generally are of benign nature. (WAHLGREN.)

In reference to the first of these cases it should be pointed out that out of GESCHIKTER and COPELAND's 27 cases of *giant cell tumours*, originating from tendon sheats, 18 were localised to the metacarpo-phalangeal or the interphalangeal joints, mostly on the flexor side. These giant-cell tumours of tendon sheaths are really found, as a rule, to derive their origin from sesamoid bones. Where sesamoid bones exist, there these tumours will also be found. In the above case the tumour was



a b c d

Fig. 11. Tumours of soft parts with defects in terminal phalanges.
a and b = benign giant-cell tumour originating from tendon sheath.
c and d = fibromyoma.

located at the distal interphalangeal joint of the index finger, a usual place for a sesamoid bone. Giant-cell tumours of this nature are as a rule small in size and of benign nature. The above mentioned authors had three cases where the bone had been affected. RAGINS has found 6 cases from literature where the adjacent bone was involved. In the case described above, however, it is only a question of pressure erosion and not of any true encroachment upon the corticalis.

SUMMARY

Cases are submitted in contribution to diseases of the bones of the terminal phalanges. Pictures are shown of 17 cases. Among these there are 4 cases of osteitis, included to show that, roentgenologically, there may be some resemblance to other conditions. Amongst the other 13 cases we find represented a number of diseases, benign lymphogranulomatosis, RAYNAUD's disease, gout, post-traumatic epithelial cysts, glomus tumours and chondroma. Two cases of tumour originating from soft tissues had caused defects in the terminal phalanges. One of these was a giant-cell tumour originating from the tendon sheath, the other one a fibromyoma. In all the cases but one the pathoanatomical diagnosis (P. A. D.) was established (Fig. 9). The possibility of epithelial cyst or enchondroma is here discussed. In reference to the cases brief summaries are made from the literature.

ZUSAMMENFASSUNG

Verf. gibt kasuistische Beiträge zu den Krankheiten in den Knochen der Endphalangen, und versieht sie mit Abbildungen von 17 Fällen. 4 von ihnen sind Osteitiden, die einbezogen wurden, um zu zeigen, dass deren Röntgenbilder denen von anderen Krankheiten gleichen können. Unter den übrigen 13 Fällen finden wir eine Anzahl von Krankheiten vertreten, Lymphogranulomatosis benigna, Morbus Raynaud, Gicht, posttraumatische Epithelzyste, Glomustumor und Chondrom. Zwei Fälle mit Tumoren,

von Weichteilen ausgegangen waren, gaben Defekte in den Endphalangen. In einem dieser Fälle handelte es sich um einen von der Sehnenscheide ausgegangenen Riesenzellentumor, und im anderen um ein Fibromyom. In sämtlichen Fällen ausser einem lag eine P. A. D. vor (Abb. 9). Hierbei wird die Möglichkeit einer Epithelzyste oder eines Enchondroms erörtert. Auf die Besprechung der Fälle folgt eine kurze Zusammenfassung der Literatur.

RÉSUMÉ

L'auteur nous soumet, cas pour cas, une description d'altérations de l'os de la dernière phalange. Ces cas, au nombre de 17, sont illustrés et quatre d'entre eux, des ostéites, ont été choisis afin de bien mettre en relief l'éventuelle parenté radiographique pouvant exister avec d'autres lésions. Parmi les autres 13 cas citons: une lymphogranulomatose bénigne, un mal de RAYNAUD, une goutte, une kyste épithélienne résultant d'un trauma, une tumeur glomique et un chondrome. Deux tumeurs, issues de tissu non-solide ont fait sentir leurs effets sur l'os des phalangettes. La première est une tumeur de cellules géantes, partie de la synoviale tendineuse, la seconde, un fibromyome. Pour tous les cas sauf un l'autopsie a été pratiquée — fig. 9 —. La question kyste épithélienne ou enchondrome fait ensuite l'objet d'une discussion, suivie de descriptions succintes de cas provenant de la littérature.

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FROM THE UNIVERSITY CLINIC ROENTGEN DEPARTMENT, OSLO
(CHIEF: PROFESSOR TORLEIF DALE, M. D.)

POLYOSTOTIC FIBROUS DYSPLASIA[1]

by

Torfinn Denstad, Oslo

The many cases referred from recent years with complete healing of hyperparathyroidism after extirpation of parathyroid adenomas, to a great degree has increased the interest in and familiarity with this lesion, and as the picture of disease is clearly defined the diagnosis is generally easy. Cases have been referred, however, which have some features in common with hyperparathyroidism, the diagnosis of which has been unclear, and as it is of importance to the greatest extent possible to identify and group such indefinite pictures of disease, I shall record here — in connection with the description of one case — a skeletal lesion which is probably less well known.

The data regarding the patient in question have been obtained from the Surgical Department A. and the Department A. of Internal Medicine, both of the University Clinic at Oslo, which have been kind enough to place the case reports at my disposal:

A woman, 18½ years old, of healthy family, when 7 years old slipped on the floor, fell sideways and fractured the shaft of the left femur, thus by a comparatively slight trauma. After some months in bed the fracture had healed in good position. She felt perfectly well until about one year ago, approximately 10 years after the fracture, she commenced having indistinct, piercing, non-radiating pains in the region of the left hip, particularly when weight-bearing, but occasionally also spontaneously. Shortly afterwards she commenced limping, and as a roentgen examination was alleged to have revealed changes in the left hip, she was in the first instance sent to bed for 3 weeks. Later she has been up, but has kept quiet. As her condition did not improve, she was admitted one year ago (4/5 1938) to the University Clinic Surgical Department A. The general condition has been satisfactory. Except for the above mentioned lesion, she has always been in good health.

Physical examination revealed a slight upward displacement of the shaft of the left femur just above the middle, as also slight tenderness in response to pressure here. The bone also seems to be somewhat bowed, and is 2 centimetres shorter than the right. There is further slight atrophy of the musculature. Walks with a limp.

[1] Submitted for publication, Sept. 25, 1939.

The general examination disclosed nothing abnormal, and neither did usual examination of the blood. Sedimentation rate 3 mm. Wassermann negative. Pirquet negative. The calcium content in blood serum was 10.35 mg. per cent, and the phosphatase content 2.86 units, representing perfectly normal values.

Roentgen examination (fig. nos. 1—2): In the diaphysis of the left femur, from the greater trochanter and downwards to below the middle, are seen a number of probably continuous rarefactions, which have resulted in a considerable upward displacement of the bone and extreme thinning of the cortex. Below the greater trochanter the cortical bone is greatly reduced, paper thin, without any definite perforation, however. In the lower part of the diaphysis similar changes are seen, less pronounced. The condyles of the femur have a slightly mottled, porotic appearance. No distinct rarefaction here, however. The upper half of the femoral diaphysis is somewhat outward bowed anteriorly laterally.

Similar rarefactions with upward displacement of the cortex, somewhat less pronounced however, are found in the proximal metaphysis and diaphysis of the left tibia, and also in the fibula in the shape of a rarefied region, the size of an almond, in the transition between the middle and lower third.

The skeleton otherwise demonstrates no pathologic changes, particularly no generalized osteoporosis or sclerosis of the skull.

The patient then was operated on (Professor JOHAN HOLST M. D.). The bone was thin like parchment and bulged outwards. It was opened, and some of the inside mass scraped out. In the middle of the femur a cyst was revealed with serous content, a slight, greyish, velvety coat lining the wall, farther up a yellow, gelatinous, partially also hemorrhagic mass.

Microscopy: Osteitis fibrosa (benign giant cell tumour). (More of this later.)

Associated with the operation a fracture occurred at the site of operation, which healed in fairly good position in the course of three months. She was discharged on September 1st 1938.

When travelling home, as she was proceeding from a car on to the train, she heard a crack in the left femur. Roentgen examination at her home place disclosed refracture. After this had been treated for some months she again had a fracture in the same place.

In the course of the last half year the tumour in the left tibia is alleged to have increased in size, and she has occasional aching pain here, particularly when walking. On April 25th 1939, therefore, she was readmitted, first into the Surgical Department A. and later into the Department A. of Internal Medicine for determination of the calcium metabolism. Ordinary clinical examination at this time, particularly with a view to disturbances of internal secretion, disclosed no abnormality. Determination of the basal metabolism, serum proteins, and non-protein nitrogen, revealed normal values. Further was found: Calcium 10.78 mg. per cent., phosphorus 3.60 mg. per cent, phosphatase 5.4 units — the latter value is thus slightly elevated.

Renewed roentgen examination of the entire skeleton demonstrated that the process in the femur was somewhat increased, in that the cortical bone had become still thinner, and the rarefied areas extending farther downwards than previously. Just below, and on the outside of the lesser trochanter, an operative defect was observed, and at the same level a healed fracture. The affection of the tibia and the fibula appear unchanged.

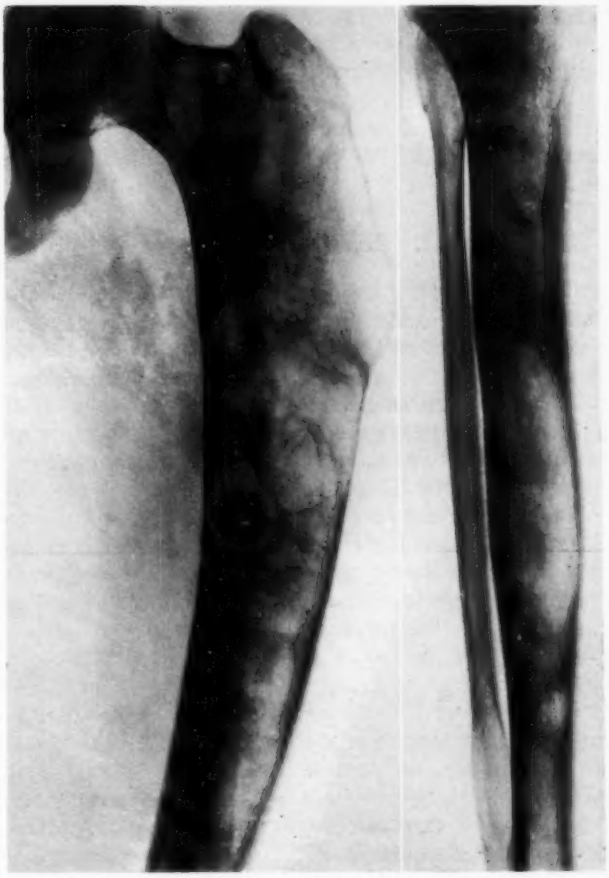

Fig. 1. Fig. 2.

No generalized osteoporosis. Slight atrophy in the region of the left ankle, probably due to inactivity.

When evaluating the picture of disease presented by this case, the following lesions must be taken into consideration:

1. Bone cyst

Occurs most frequently in children, particularly at the age of from 6 to 10 years. They are almost always solitary. The place of predilection

is the proximal metaphyses of the humerus, femur and tibia. Correspond ing with the bone growth, however, they may migrate into the diaphyses They contain a clear, more or less hemorrhagic fluid. Spontaneous frac ture, generally in the form of infraction, is frequent. Roentgenologicall is found a sharply defined, generally solitary, rarefaction with extrem cortical thinning and slight, very rarely more extensive, spindleshape upward displacement.

2. Giant cell tumour

Most frequently these make their debut at ages between 20 and 3 years, and these also are almost always monostotic. The place of predi lection are the epiphyses of the long bones, most frequently the dista femoral epiphysis, the proximal tibial epiphysis, and the distal radia epiphysis. On rare occasions, however, the tumours may be localized to the metaphysis, in which position there may be a considerable upward displacement of the bone with paper thin, partially perforated cortex, with sharp outline against the normal.

It is obvious that none of these conditions are quite in conformity with the picture presented by the case referred.

The lesion, to which it is of the utmost practical importance to take a standpoint, and which one may perhaps in the first instance have in mind due to the extensive rarefactions, is

3. Hyperparathyroidism

The bone lesion accompanying the disease, Recklinghausen's osteitis fibrosa generalisata, first and foremost is characterized by a generally dispersed porosis, and in practically all cases thickening of the cranial vault. One frequently finds also bone cysts and giant cell tumours, as a rule with the same localization and the same characteristic appearance as mentioned above. The disease occurs most frequently in women at the ages of from 20 to 50 years.

The roentgenograms in this case are in themselves sufficient evidence that hyperthyroidism may be practically speaking excluded, the general porosis being completely absent, as also changes in the skull. The onset of symptoms in childhood also speak against the diagnosis. Further, no increase has been demonstrable in the blood calcium, no reduction in the phosphorus content, and only a negligible increase of the phosphatase. Even if an elevation of the calcium level in the blood may not be an absolute condition for establishing the diagnosis, no findings have been secured, at any rate in this case, which may be taken to indicate an increased functioning of the parathyroid glands. The

alcium balance of the patient has not been examined, which to my nowledge is always »negative» in the presence of hyperparathyroidism.

By which condition are we then confronted in this case?

In »Archives of Surgery» of May 1938 LICHTENSTEIN has published paper dealing with a skeletal lesion, which purely descriptively he desgnates »polyostotic fibrous dysplasia». Personally he has collected 8 ases, all of which have been verified microscopically. He points out, owever, that the condition is sure to have been recorded previously nder descriptions such as: osteodystrophia fibrosa unilateralis, unilateral ecklinghausen's disease, unilateral polyostotic osteitis fibrosa, osteitis brosa in multiple foci, and so forth, and that it is not rare. The Regional ibrocystic Disease described in NELSON's »Loose-Leaf System» (Diagnosc Roentgenology) probably also refers to the identical lesion. LICHENSTEIN contends that the cases he has observed personally have so any features in common that it is justified to differentiate them as a stinct clinical entity.

The symptoms, which generally consist in limping, pain, deformity, and perhaps the most frequent symptom: pathological fracture of the affected bones, have their onset in childhood and adolescence. It is usually women who are affected. The disease evolves slowly. The majority of patients do not consult a physician until they are in their twenties. In one case the symptoms had lasted for 36 years. Mostly several bones are affected, and the tendency of unilateral localization is characteristic of the lesion, even if exceptions are noticed. The femur and the tibia are affected most frequently. Also the humerus, the radius, the skull, the pelvic bones, the ribs, the phalanges, and the other bones preformed from cartilage as well as from fibrous tissue. The disease is localized to epiphysis and metaphysis as well as diaphysis.

Roentgenologically is revealed a rarefaction of the affected bones of the appearance of a cyst and correspondingly great thinning of the cortex and expansion of the bone. Further are often observed secondary deformity, particularly as an augmentation of the normal bowing. Pathological fracture, especially of the femoral collum, is frequent.

Pathologic anatomic examination reveals the medullary cavity filled by a greyish-white tissue of a peculiar spongy or elastic, apparently gritty consistency. Microscopically are detected spindle cells, indistinctly defined, with oval, pale-staining nuclei, and in some places ample collagenous fibres. Evenly dispersed are further seen small trabeculae of poorly calcified bone (compare the palpable granules) developed by osseous metaplasia without osteoblastic function, particularly in the most vascular areas. There are few osteoblasts. The tissue on the whole is relatively avascular. In some regions, however, one may encounter some capillaries and occasionally small arterioles, partially in close

proximity to the trabeculae. As evidence of previous capillary hemorrhages, which have been resorbed, are found granules of hemosiderin within phagocytes, and in their vicinity one may encounter small nests of giant cells, which may have as many as ten or more nuclei. Most giant cells are distributed in the connective tissue. One may also find scattered islands of hyaline cartilage. The thinning of the cortical bone is due in part to resorption, but largely also to erosion from the inside caused by the proliferating connective tissue, which fills the medullary cavity. There are no evidences of periosteal neoplasm (except in connection with spontaneous fracture). Lipoid tissue has not been demonstrated. There is no histological evidence of the presence of a tumour, no mitoses and no cellular atypism. Clinically no instance has been observed of malignant degeneration. Nor is there any evidence suggesting an infectious genesis.

Taking into consideration the early onset, LICHTENSTEIN contends that the disease is congenital, an anomaly of skeletal development consisting in a functional disturbance of the boneforming mesenchyme. Normally this gives rise to the substantia spongiosa and to the red and yellow medulla. He maintains that under pathological conditions bone may develop by osseous metaplasia, hyaline cartilage by cartilaginous metaplasia, connective tissue with collagenous fibres by fibroblastic differentiation, and giant cells by coalition. The development of hyaline cartilage is of considerable theoretic interest, in that it suggests a possible relation to another anomaly of skeletal development, skeletal enchondromatosis. The unilateral localization also points to OLLIER's disease, a rare form of dyschondroplasia, which is also a hereditary anomaly of skeletal development, but with an entirely different appearance.

Estimations of the serum content of calcium, phosphorus and phosphatase reveal normal or negligibly elevated content of calcium (9.8 to 11 mg. per cent-other investigators up to 11.6 mg. per cent), normal phosphorus. The phosphatase, however, was increased (up to 22 units). This latter finding in LICHTENSTEIN's opinion supports the hypothesis of BODANSKY and JAFFE, that the activity of the phosphatase is proportional to the formation of new bone. He also found the lowest phosphatase value (4.1 units) in a patient in whom microscopy revealed the least tendency to formation of new bone, in contradistinction to two other cases with a much greater tendency to formation of new bone, and with values of phosphatase of 22 and 17 units respectively.

It is instantly apparent that the case report referred, as well as the clinical findings together with the laboratory examinations as also the roentgenological examination, in all details conform to the picture of disease portrayed by LICHTENSTEIN in connection with »polyostotic fibrous dysplasia».

One of the cases referred by LICHTENSTEIN is so identical with that of the patient mentioned here, that I shall give a brief report:

A woman, 19 years old, was admitted into hospital due to pain in the right hip and thigh, which she had had since a fall at the age of 8. She was at that time treated with several months' stay in bed. Physical examination revealed 2.5 centimetres of shortening of the right lower extremity. According to the description, the roentgen examination appeared to demonstrate the identical findings as described above, also with a healed fracture. Similar changes were revealed in several ribs. No abnormal findings by examination of the blood, etcetera. Biopsy was made from a rib. Microscopy showed the typical picture. Later she also developed pain in the right leg, and similar changes were found in the tibial diaphysis. Roentgenological control nine years after the first stay in hospital demonstrated unchanged conditions; if anything slight progression. The following year she was operated upon with a view to possible parathyroid adenoma, without any such being detected.

The one factor which does not appear to fit in is the microscopic finding, in that the diagnosis, as mentioned, was established as osteitis fibrosa (benign giant cell tumour). The specimens have been re-examined, however, by JOHAN STANG, who states: »As compared with the histological findings in LICHTENSTEIN's case, a polyostotic fibrous dysplasia may very well be present in this case. It is particularly notable, that the newly formed bone is poorly calcified, which is emphasized as being a characteristic feature of the condition, and which is not found in the specimens of benign giant cell tumours which I have gone through in this connection».

It is of the utmost importance to establish an exact diagnosis in such cases. It is a fact, namely, that on account of the cystic appearance of the affected bones the condition is generally misinterpreted as due to hyperparathyroidism, and from the literature LICHTENSTEIN has unearthed six cases with the typical picture of polyostotic fibrous dysplasia, which have been operated upon without any adenoma having been detected originating from the parathyroid. Further, there is a later case, recorded by GARLOCK, and which was operated upon twice with negative result, the first time on account of a serum calcium content of 13 mg. per cent (by a subsequent determination 11.3 per cent), the second time after demonstration of a negative calcium balance. It is a doubtful question, however, if decisive importance may be attributed to a demonstration of negative calcium balance at one single determination, as erroneous sources occur in the examinations. GOLDHAMER also has referred one case, which he designates as osteodystrophia fibrosa unilateralis, and which — to judge from the description — is probably a case of polyostotic fibrous dysplasia. As in this case also the blood calcium was slightly elevated, the patient was operated upon. No adenoma was found, however.

I have referred this case in order to render more familiar a condition, which in the opinion of LICHTENSTEIN is not so rare, and perhaps in this

way contributing towards the aim, to prevent these patients being subjected to an unnecessary operation. The treatment consists in prophylaxis against fracture. Curettage of the content of the medullary cavity, and possibly bone implantation, are supposed to be of no use, as fresh connective tissue is formed in the cavity. The activity of the lesion decreases gradually with progressing years. The normal bony structure is not regenerated, however.

SUMMARY

A case is described of polyostotic fibrous dysplasia with characteristic thinning and upward displacement of the cortex, mainly localized to the diaphysis of the femur, the tibia and partly fibula, on one side. As typical for the lesion the symptoms commenced with pathological fracture in childhood, and not until late in the second decade of life the patient consulted a physician because of pain and limp. The importance is stressed of differentiation against other skeletal lesions, particularly hyperparathyroidism with osteitis fibrosa generalisata.

ZUSAMMENFASSUNG

Verf. beschreibt einen Fall von polyostotischer fibröser Dysplasie mit charakteristischer Verdünnung und Aufwärtsverlagerung des Kortex bei einseitiger Lokalisation hauptsächlich an der Diaphyse des Femurs, der Tibia und zum Teil auch der Fibula. Wie es für das Leiden typisch ist, begannen die Symptome mit pathologischer Fraktur im Kindesalter, und erst im späteren Teil des zweiten Lebensjahrzehnts zog der Patient wegen Schmerzen und Hinken einen Arzt zurate. Verf. betont die Bedeutung der Differentierung gegen andere Skelettläsionen, besonders gegen Hyperparathyreoidismus mit Osteitis fibrosa generalisata.

RÉSUMÉ

L'auteur décrit un cas de dysplasie polyostotique fibreuse avec amincissement caractéristique et déplacement vers le haut du cortex, unilatéralement localisée et particulièrement au diaphyse du fémur, du tibia et partiellement du péroné. On peut ramener le cours de la maladie au développement suivant: elle commence dans l'enfance par une fracture pathologique, et ce n'est que vers la deuxième décade de sa vie que la malade se décide à consulter le médecin en prétextant des douleurs et une démarche défectueuse. On insiste sur les différences que présentent d'autres lésions squelettiques, particulièrement celles dûes à l'hyperparathyroïdisme avec ostéite fibreuse généralisée.

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FROM THE ROENTGEN CLINIC OF THE BISPEBJERG HOSPITAL, COPENHAGEN, DENMARK
(SENIOR ROENTGENOLOGIST: CHR. I. BAASTRUP)

THE DIAGNOSIS AND ROENTGEN TREATMENT OF CERTAIN FORMS OF LUMBAGO[1]

by

Chr. I. Baastrup

In a couple of earlier papers I have already called attention to some changes in the lumbar and 1st sacral vertebræ and the soft tissues between them, as the cause of certain forms of lumbago. I beg leave to recapitulate briefly what I wrote there, and to supplement that recapitulation with the observations I have made and the further conclusions I have come to since those former papers were published.

The changes in the spinous processes are found specially in subjects of advanced age; in fact, they may be said to be an almost constant finding in such individuals, though, of course, in varying degree, just like spondylotic changes and atherosclerosis. They may be found corresponding to a single interspinous space, or to several or all of the spinous processes of the lumbar and the 1st sacral vertebræ. All the changes can be imagined to have occurred as the result of pressure of one spinous process against another.

The height of the space between the spinous processes can in normal subjects vary considerably, not only in different individuals, but of course also in the same individual according to the more or less lordotic posture assumed. It is hardly possible to say how narrow it can be physiologically, or where the limit between the physiologic and a pathologic condition should be drawn. But when the bone edges of two contiguous spinous processes show pathologic changes due to pressure it must be supposed that the interspinous soft-tissue pads have first been injured. These pads may become destroyed to a greater or lesser extent, and in extreme cases become entirely obliterated. The form of the interspinous spaces may become changed as the result of changes in the

[1] Introductory paper read at the meeting of the 9th Congress of the Northern Association of medical Radiology, in Copenhagen, June 1938; submitted for publication Nov. 11, 1939.

shape of the processes themselves. While, under normal conditions, the spaces are higher anteriorly than posteriorly, they may under pathologic conditions become equally high all through (Fig. 1).

Laterally displaced spinous processes remind one of teeth that are badly set owing to insufficient space in the jaw. Such a position of the processes will undoubtedly as a rule have been acquired in early childhood, and may considered as a physiologic variant, which, however, disposes to pathologic conditions. Also faceting of the upper and lower edges of the processes seems sometimes to date from early life; in other cases it is a secondary phenomenon, and may then be found coincidently with osteosclerosis and other osteoarthritic lesions (Figs. 2, 3 and 4).

Calcification of the ligaments in the form of spur formations may be considered as almost physiologic in subjects of advanced age, just like spondylotic excrescences on the bodies of the vertebræ. Sometimes small shadows may be seen, which are due to local lime deposits in the supraspinal ligament, and which may possibly be remnants of hematomata due to lesion of the ligament, like the corresponding phenomena which may be observed in the anterior longitudinal ligament.

The dimensions of the spinous processes may become increased both vertically and horizontally. Their edges may be thickened or become deformed by osteophytes, and their structure at the upper and nether edges become osteosclerotic. The tissue may break down and become spongy, with subchondral cysts. The processes may become fractured or ankylosed to each other. Fragments like sequestra may be observed. Such structural changes, ankylosis and the formation of sequestra are always pathologic phenomena and of precisely the same type as commonly seen in the case of chronic, osteoarthritic processes in hip- and knee joints.

That the pressure of the spinous processes against each other can become so strong that pathologic changes are produced is due partly to the lumbar lordosis,[1] partly to the circumstance that the processes are the short arm of the system of levers formed by the vertebræ; and to this must be added a number of other, different causes, namely:

1. increased lordosis as seen when there is gibbus owing to tuberculous spondylitis (Fig. 1), in cases of spinal fracture (Fig. 4), of spondylolisthesis, of certain kyphoses and scolioses, of congenital luxation of the hip joint, etc.; also in cases of adipositas, abdominal tumors and gravidity, where the accentuation of the lordosis is due to increased weight and the attempt to compensate the latter; and finally in asthenic conditions, where the muscular corset fails to give the necessary support;

[1] Man is probably the only mammal with lumbar lordosis. The affection which so often causes lumbago may be considered as an expression for incomplete adaptation to the erect posture.

Fig. 1. — Increased lordosis in Case of tuberculous spondylitis. — Height of space between the spinous processes the same anteriorly and posteriorly. Facets. Osteosclerosis.

2. increased volumen of the spinous processes (Paget's disease and fluorosis);

3. shrinking of the vertebral bodies and intervertebral discs (a phenomenon of old age)[1];

[1] The stooping manner in which so many old people carry themselves may be due to this shrinkage, but also to an unconscious effort to increase the distance between the spinous processes and thus avoid pain.

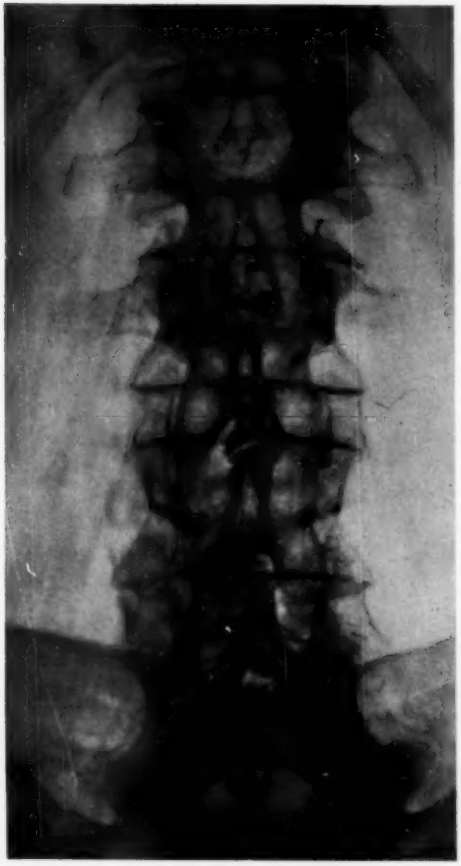

Fig. 2. — Close-set spinous processes with facets, spongy tissue, osteosclerosis and osteophytes.

4. spondylosis deformans[1];

5. congenitally high spinous processes or low vertebral bodies, or both.

All these observations and considerations naturally explain the term »disposition to lumbago».

It must be possible for the development of the osteoarthrotic changes in the spinous processes to be accompanied, just like similar changes in other parts of the bone system, by diverse clinical symptoms. I shall here mention only sudden attacks of pain and more permanent pains; in other words, acute and chronic lumbago. The most frequent direct causes of pain are undoubtedly tension in hematomata, reactive edema, perhaps also sometimes actual irritative processes in the periosteum or ligaments; while protracted muscle contraction is the most common secondary cause. But of course none of these factors can be demonstrated roentgenologically. Osseous changes, on the other hand, are probably to a much lesser extent a direct cause of pain. This may explain why one may

[1] Exostoses on the spine are situated on the concavities oftener than on the convexities. The concavity of the lumbar portion is directed backwards. Patients with spondylosis deformans straighten the lordosis and fix their back in that position. As a result, the exostoses on the anterior part of the vertebral bodies become pressed against each other, while the distance between the spinous processes becomes increased. From this it is reasonable to suppose that in this disease the pain-centre most often is situated posteriorly. KAHLMETER says that in spondylosis deformans there is tenderness to pressure in the mid-line of the back, while pressure in the longitudinal axis of the body does not elicit pain.

sometimes see enormous lesions of the spinous processes in cases where the patient does not complain of pain at all, and, conversely, encounter indubitable attacks of »spinous-process lumbago» where there are no roentgenologically demonstrable lesions of those bones.

»Acute back ache» is as a rule stated by the patient to have been the immediate sequel to a forwards or backwards bending, or sideways twisting, of the back, oftenest following some effort or sudden, rapid movement; as, for instance, in the case of a drayman who believes that a case which he is going to lift contains filled bottles, but as the bottles happen to be empty he puts far too much force into the movement, with the result — acute lumbago. Many persons get lumbago from horseback riding, which causes the spinous processes of the lumbar spine to pound incessantly against the soft interspinous tissues. That close-set spinous processes may strike against each other, or overshoot, and thus produce a lesion resulting in hematoma, is easily understood. I have formerly published a case of fracture of spinal processes resulting from the patient's bending backwards under a very violent effort. Von Krueger's experiments with dead bodies prove the same; when he bent the lower part of the trunk forcibly backwards, the spinous processes of the lower lumbar vertebræ became fractured.

Fig. 3. — Close-set spinous processes with facets, osteophytes and incipient ankylosis.

That inclination forwards can cause lumbago is perhaps more dif-

Fig. 4. — Fracture of the body of the 12th thoracic vertebra. Marked osteosclerosis and osteophytes along the edges of the spinous processes of the lower lumbar vertebræ.

ficult to understand. It is possible, however, that the interspinous ligaments may be diseased owing to pressure from the processes, and therefore fragile. If that is the case, excessive tension may cause them to break. In this connexion it is interesting to remember DYE's description of increased distance between the spinous processes in cases of fracture of vertebral bodies that have become wedge-shaped through degeneration. This increase must be due to rupture of the interspinous and supraspinous ligaments. JAEGER has found it in one-third of all fractures of such vertebral bodies. In a similar case I found myself that *the inferior portion of the spinous process above the fractured vertebral body had been broken off*, — a fracture which has not to my knowledge been described before, but which is a counterpart to the strain-fracture described by JAEGER, of the lower, anterior edge of cervical bodies, due to backwards inclination of the neck (Fig. 5).

The course and duration of an acute lumbago (acute back ache) fit very nicely with the theory according to which the pain, which as a rule is strongest the day after the beginning of the attack, is due to a hematoma. The question is now whether this hematoma, and the lesion which is the cause of it, as hitherto supposed have their seat in the muscles of the loin, or whether the lesion is localised to the spinous processes and the tissue between them, and the contraction of the loin muscles thus

a secondary phenomenon. BIRCHER, who has examined the musculature of lumbago patients operatively, has never been able to find any hematoma; and ZOLLINGER and POMETTA maintain, on the basis of a very large material, that the symptoms in acute lumbago are unlike those produced by rupture of muscles in any other part of the body. In many experiments on patients with spinous-process lumbago I have found that an injection of novocain between the processes will stop an acute or chronic attack in the course of a few hours, while some tests with novocain injection into the muscles where the pain was felt did not give any relief. Also the good result of some operations performed on spinous processes in cases of chronic lumbago, with complete or partial resection of such processes, seems to indicate that the cause of the pain is to be found in the latter, or in the tissue between them (WESSEL, GUILDAL, KAPEL, SEMB et al.).

Fig. 5. — Fractures of the bodies of the 12th thoracic and 1st lumbar vertebræ. Strainfracture of lower edge of spinous process of 12th thoracic vertebræ. Increased distance between the latter and adjoining processes.

Woman, aged 46 years. — Bispebjerg Hospital Feb. 8th—15th, 1938. — Her general health had always been good hitherto; specially never any trouble with her back. Two days after a severe attack of influenza she had now suddenly got strong pain in that locality, localised to the mid-line, corresponding to the spinous processes of the second to

fourth lumbar vertebræ. A very tender swelling, about the size of a large crab-apple, developed there, and grew slightly larger in the following couple of days. The patient was practically unable to turn in her bed, and suffered intense pain; but both the pain and the swelling subsided completely in the course of two-three weeks, and have not recurred since. Roentgen examination showed normal conditions in the spine. When the pain had moderated somewhat, an injection of novocain was made between the spinous processes, whereupon the pain disappeared within a few hours. *Diagnosis:* hematoma between the spinous processes of the second to third and third to fourth lumbar vertebræ. Enfeeblement owing to influenza may have been a disposing factor for the trauma.

Hitherto, a distinction has usually been made between secondary and primary lumbago; the secondary occurring on the background of scoliosis, sacralisation, etc., inflammatory or tumorous affections of the columna or spinal marrow, affections of the abdominal — specially the urinary and genital — organs, infectious diseases, etc.; while the primary, so-called »true» lumbago has been diversely regarded as traumatic (due to rupture of lumbar muscle fibres) or as »rheumatic», — a nebulous term, likewise based on the idea of some connexion with the musculature. The violent contraction of the muscles which takes place in lumbago makes this conception readily understood. In my opinion, the pathological concept of an idiopathic lumbago might well be done away with, however. For also in these cases the muscular contraction is determined by some underlying cause, generally an affection of the soft-tissue pad between the spinous processes, of the intraspinous or supraspinous ligaments, of the periosteum and osseous tissue of the processes; or possibly some other affection of the spinal column, — for instance pathologic changes involving the articulations. In a former paper I said that the view here presented does not explain the connexion between lumbago and ischias; but my observations since then, of various phenomena related to the problem, seem to furnish a rational explanation also of this connexion. I hope to deal more fully with this subject in a forthcoming communication.

I have called the disease in the spinous processes: *osteoarthrosis processus spinosi.* STEHR, of the Rudolph Virchow Hospital in Berlin, who fully shares my views, suggests the appellation: *osteoarthrosis interspinosa.*

The treatment of an acute attack of spinous-process lumbago will not be different from the one ordinarily employed in cases of acute back ache, namely rest, heat, analgetics, etc. While the treatment is in progress, the hematoma will become resorbed. Pain due to strong, persistent contraction of the muscles may probably be relieved by massage.

In chronic cases, the usual forms of physiotherapy may be tried; but if they do not prove effective within a short time, roentgen treatment should be instituted. If that, too, fails of effect, the patient should, if the case permits, be fitted with a corset, in order to obtain ankylosis; or, if the circumstances indicate it, an operation be performed, with partial or entire resection of the diseased spinous processes, or possibly an Albee's operation. As to how long the various forms of physiotherapy should be kept on with before roentgen treatment is instituted, opinion will probably differ, — at least in Denmark, where the use of roentgen therapy in rheumatic diseases is not particularly common.

I am able to report the results of roentgen treatment in 43 cases of chronic lumbago, all of them supposedly spinous-process lumbago. Cases of lumbar pain for which there might be other demonstrable causes, such as metastases from cancer, myelomata, avitaminotic osteomalacia, etc., are not included, even though there were also marked lesions of the spinous processes. Also cases of ankylopoietic spondylitis are left out; of which it may incidentally be remarked that in the few cases of this kind which were sent to us for irradiation, this treatment appeared to have a good effect against the pain.

Of cases of spondylosis deformans, none have been included in which there was distinct degeneration of vertebral discs, or nuclear herniæ. According to my experience, such forms of spinal disease are not very favorable objects for roentgen treatment. On the other hand, our material includes many cases with osteophyte formations on the anterior edges and sides of the vertebral bodies. Such formations are, of course, almost normal occurrences in subjects of advanced age, and, so far as I can judge, hardly a cause of pain. Nor have light forms of spina bifida, which, as we know, is found in 30 per cent of all individuals, been eliminated; nor very slight degrees of sacralisation and lumbalisation. Further included are 3 cases in which the anterior upper edge of one of the vertebral bodies formed a corpus liberum. In regard to some of the cases it was difficult to decide whether polyarthritic factors might not possibly have had something to do with the condition. Thus, it may be difficult, for instance, to judge whether a malum coxæ senile with secondary changes in knee-joint and spine is polyarthritic or arthrotic. As regards the material I am presenting here, we have, however, done our best to eliminate all cases where there was likelihood that the pain might be due to any cause other than the affection of the spinous processes. Straight cases — in the sense that no affection other than this can be demonstrated — are uncommon, though; because the changes in the spinous processes, like all arthroses, are, of course, secondary phenomena. Besides, it must be remembered that the pain in lumbago, as already said, undoubtedly is intensest at the time when the soft

tissues are becoming destroyed; consequently before the roentgenologic changes have become very conspicuous, or perhaps even demonstrable, at all.

The effect of the irradiation is only analgetic, not curative. We ignore absolutely what actually causes the rays to have this effect of quieting the pain. It is very difficult properly to evaluate the results of roentgen treatment of lumbago. Firstly, because it is a question of a subjective symptom, pain. Besides, this pain may cease spontaneously for shorter or longer spells, and, finally, the roentgen treatment will in most cases be combined, at least for a time, with other therapeutic measures, such as relief from work, rest, hot applications, salicyl preparations; we have even discovered cases in which patients, without saying anything to us about it, took massage, medicinal baths, diathermy, short-wave and other treatments concurrently with or after the roentgen.

In some patients, protracted pain and long time's failing capacity for work has produced a neurasthenic condition which also makes it difficult to form a clear estimate of the result of the irradiations; in other cases the question of compensation — not least the so greatly coveted »invalid's pension» — undoubtedly does that an actual improvement is not always properly acknowledged by the patient. Conversely, of course, the psychic effect of the roentgen treatment must not be forgotten. But as a result of all this, the evaluation of the cases becomes rather uncertain, and does not lend itself well to presentation in strict, statistical form.

Even in cases where the patient states that the pain has disappeared completely as a result of the treatment, and has not returned in the years since, it is hardly justified to speak of a cure. In the first place, our earliest cases date from 1934, and four years are undoubtedly an insufficient observation period on which to base a definite conclusion. Besides it is also in cases of spontaneous remission seen that there may be freedom from pain for that length of time.

In this paper I have spoken only of conditions in the back, without reference to the corresponding affections in articulations of the extremities which might be present at the same time. It was noticeable how often the lumbago pain in such cases would recede more rapidly and more completely under the roentgen treatment than, for instance, the pain in hip- or knee joints, even when the dosage to the spine was smaller. Also the tendency to recurrence of the pain seems to be less in the spine; of the reverse I have not observed any instance. Spinous-process lumbago would thus seem to be a more gratifying object for roentgen treatment than arthroses in the articulations of the extremities.

On the whole, the treatment has been built up on the lines laid down by ÅKERLUND; but at the same time it has been highly individualised. The single dose has nearly always been of 300 r; intensity, 18; filter, 0.2 mm. Cu. + 6 mm. Al.; focus-to-skin distance, 40 à 50 cm. In most cases, 3 doses of 300 r were given at intervals of six weeks; sometimes only one such dose of 300 r. The largest total dose given in any case was 9 × 300 r, distributed over four years. As a rule, the patient has been free from pain for a shorter or longer period after 3 × 300 r. If the pain returned, another two or three doses of 300 r have been given, with intervals of six weeks as before. Only in four cases was the patient given more than 3 × 300 r within a year. The interval between two series of treatment has in no case been less than 3 months. After the experience which I have more recently gathered in Sweden (RENCK) I am inclined, however, to try in the future with slightly smaller doses.

The distribution of the 43 cases according to sex and age of the patients is as follows:

	20—29	30—39	40—49	50—59	60—69	70—80
Improved;						
Male	1	2	3	4	2	
Female		1	3	9	6	2
Not improved;						
Male				3	1	
Female		1	3	1		1

Thus, of a total of sixteen men, 12 improved, 4 not improved; of a total of twenty-seven women, 21 improved, 6 not improved. Of the cases which failed to improve, there was none of which it could with any degree of certainty be said that the condition had become worse. With so small a material, a percentage-calculation is, of course, without much value; but merely as an indication of the results it may perhaps be permissible to state that improvement was obtained in 77 per cent of the cases treated. Quite apart from the possibility that statistics covering a larger number might give a different result, and from the fact that »improvement» in most of the cases means only *temporary* improvement, it seems to me that these results may justly be considered as encouraging, not least because most of the patients of whom there has been question here are such as had first tried to find relief through a variety of other, physiotherapeutic treatments.

The patients' statements regarding the length of time during which they had been suffering pain before they began the roentgen treatment varied from a few months to as much as thirty years. These statements impress one as being very unreliable, however. There are cases in which the pain disappeared as by a miracle under the action of the rays, while

all previous treatment had been in vain. All possible gradations of effect have been observed, from such stupendous down to absolutely nil. It has not been possible to demonstrate any regularity, such as, for instance, that fresh, or comparatively fresh cases should respond better to treatment than older ones. The patient who stated that she had been suffering from lumbar pain for thirty years before she came to roentgen treatment, received *one* treatment in 1934, and as a result of that remained free from pain for $3^1/_2$ years before recurrence set in. On the other hand, two patients who had suffered from lumbago only for two or three months received no, or only a doubtful effect, from the treatment.

In some cases a single dose of 300 r has brought complete freedom from pain. In such cases we have just waited, without giving any more, and a few of these patients have not yet, up to the present, had any reccurrence (all the cases have been followed up to as late as May—June, 1938). Most often, however, recurrence sets in after the patient has been free from pain for some months or years following the roentgen treatment. In most of such cases repeated irradiation has again brought relief; in a couple of cases the first treatment seems to have given the best result.

Several patients state that after the treatment they no longer have any pain in their back under ordinary, everyday conditions, but that the pain comes again after any considerable effort; as, for instance, in the case of a woman, after a big washing-day. In such cases the treatment has not been repeated. Others state that while they are not entirely free from pain, the trouble it causes them is now too slight to necessitate further treatment.

In one case, in a woman in the late forties, cessation of the menstruation was observed. Most of the patients experience some slight indisposition, lack of appetite, nausea or the like, in connexion with the irradiation, but we have never observed any more serious symptoms accompanying or following these mild treatments. In the case of women in whom the menopause has not yet set in, it is necessary to be careful with the irradiation, however, and always to screen off the genitals well before exposure.

It will thus be seen that many cases of spinous-process lumbago, also such as have in vain been treated by various physiotherapeutic methods, may with good — even if often only temporary — effect be treated by roentgen.

SUMMMARY

The author briefly describes the disease which he calls spinous-process lumbago, »osteoarthrosis proc. spin.» (syn: osteoarthrosis interspinalis). The pressure of one spinous process on another causes destruction of the soft interspinous tissues and osteo-

arthritic changes in the processes themselves. The cause of the pressure lies in the lordosis, in the lever arrangement of which the spinous processes form the short arm, and in five groups of more individual phenomena; viz. increase of the lordosis, increase in the bulk of the spinous process, shrinkage of the vertebral bodies, spondylosis deformans and congenital disposition. The clinical symptoms produced by the pressure of the processes against each other are acute and chronic pain, and protracted muscular contraction. The author next discusses the manner in which spinous-process lumbago develops, and sets forth his views regarding acute lumbago, and the proofs by which they seem to be supported. Finally, he discusses the roentgen treatment of spinous process lumbago, and reports on 43 cases treated by that method, 33 of which were improved, while 10 were not.

ZUSAMMENFASSUNG

Verf. beschreibt kurz die Krankheit, die er Dornfortsatz-Lumbago, »Osteoarthrosis proc. spin.« (Synonym: Osteoarthrosis interspinalis) nennt. Der Druck eines Dornfortsatzes auf den nächsten bewirkt Zerstörung der weichen interspinösen Gewebe und osteoarthritische Veränderungen in den Fortsätzen selbst. Der Grund des Druckes liegt in der Lordose, im Hebelmechanismus, bei dem der Dornfortsatz den kurzen Arm bildet, und in fünf Gruppen von mehr individuellen Pähnomenen: nämlich: Zunehmen der Lordose, Zunahme der Masse des Dornfortsatzes, Schrumpfung der Wirbelkörper, Spondylosis deformans und angeborene Disposition. Die klinischen Symptome, die der Druck der Dornfortsätze aufeinander hervorruft, bestehen in akuten und chronischen Schmerzen und in protrahierter Muskelkontraktion. Verf. erörtert darauf die Art und Weise, in der sich die Dornfortsatzlumbago entwickelt und bringt seine Ansichten über die akute Lumbago vor sowie Beweise, durch die sie unterstützt erscheinen. Schliesslich bespricht er die Röntgenbehandlung der Dornfortsatzlumbago und berichtet über 43 mit dieser Methode behandelte Fälle, von welchen bei 33 eine Besserung eintrat, bei den übrigen 10 dagegen nicht.

RÉSUMÉ

L'auteur décrit brièvement la maladie qu'il appelle lumbago des apophyses épineuses, ostéoarthrosis proc. spin. (syn. osteoarthrosis interspinalis). La pression d'une apophyse sur une autre résulte en la destruction du peu-résistant tissu interspinal et a pour conséquence des altérations ostéoarthritiques dans la substance même des apophyses. La cause de cette pression est à rechercher dans la lordose, dans le système de levier où l'apophyse joue le rôle du bras le plus court et dans cinq groupes de phénomènes à caractère plus individuel: à savoir, une aggravation de la lordose, une hypertrophie des apophyses épineuses, un rétrécissement des corps vertébraux, une spondylosis deformans et certaines prédispositions congénitales. Les symptômes cliniques consécutifs à la pression des apophyses se présentent sous forme de douleurs aiguës ou chroniques et de contractions musculaires prolongées. L'auteur en vient ensuite à discuter le processus du lumbago des apophyses épineuses et présente ses points de vue en ce qui concerne le lumbago aigu ainsi que les preuves qui lui permettent de les étayer. Touchant le traitement par les rayons roentgen de l'osteoarthrosis proc. spin., il rapporte que pour 43 cas traités, 33 eurent des résultats concluants contre 10 qui n'en eurent aucun.

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MYELOSKOPISCHE UND MYELOGRAPHISCHE BEFUNDE BEI ISCHIASVERURSACHENDEN HINTEREN BANDSCHEIBENPROLAPSEN[1]

von

Walter G. Deucher

Nachdem man vor einigen Jahren die Bedeutung der *hinteren Bandscheibenprolapse* für das Zustandekommen klinischer Erscheinungen erkannte, (ADSON, ANDRAE, LOVE, MIXTER) ist es heute unbedingt notwendig, alle ungeklärten Fälle von Ischias oder Lumbago einer ganz, genauen diagnostischen Prüfung zu unterziehen, damit man dieses Leiden nicht übersieht. Nach einer Zusammenstellung aus der Mayo Clinic (LOVE) wurden von 10,000 Fällen mit Ischias und Lumbago 200 also 2 % wegen eines Bandscheibenprolapses operiert. Diese Verhältniszahl erscheint recht klein, es ist aber darauf hinzuweisen, dass in vielen Fällen von Ischias oder Lumbago ein anderes organisches Grundleiden gefunden wurde. Diese Fälle sowie diejenigen, bei denen ein rein neuritischer Ischias besteht, kommen natürlich für die Differentialdiagnose des Bandscheibenprolapses nicht mehr in Frage; der Prozentsatz von Fällen mit Ischias infolge eines Bandscheibenprolapses zu den verbleibenden »unerklärlichen» Ischiasfällen ist deshalb wesentlich höher. Da es für den Bandscheibenprolaps (Bpr) keine pathognomischen Symptome gibt ist die Wertung des klinischen Bildes in allen Fällen schwierig. Es kann nicht genug betont werden, dass unbedingt eine genaue klinische Untersuchung zum Ausschluss aller anderen möglichen Ursachen einer Ischias oder Lumbago durchgeführt werden muss bevor das Vorliegen eines Bpr als wahrscheinlich angenommen werden kann. In selteneren Fällen liegen ausgeprägte neurologische Symptome vor, die wegen ihrer charakteristischen segmentären Ausbreitung auf das Bestehen einer Markkompression hinweisen. In solchen Fällen ist das weitere diagnostische

[1] Bei der Red. am 14. X. 1939 eingegangen.

Vorgehen dann von selbst gegeben. Man wird beobachten können, dass an Kliniken, an denen die Diagnose und Behandlung von Bpr neu aufgenommen wird, am Anfang in der Regel Fälle mit typischen segmentären Störungen zur Operation kommen, während im Verlauf der weiteren Arbeit auch Fälle mit Ischias und Lumbago ohne segmentäre Störungen dazukommen werden. An Orten, an denen bereits eine grosse Erfahrung in der Beurteilung dieser Krankheit besteht, überwiegen die Fälle ohne segmentäre Störungen weitaus.

Da weitaus die grösste Mehrzahl der Bpr die Lendengegend betrifft finden sich die *Symptome* auch am häufigsten an den unteren Extremitäten. »Ischias» oder Kreuzschmerz mit Ausstrahlung gegen die Beine ist das häufigste Symptom eines Bpr, dabei ist das *Lassègue*-Symptom meist beidseitig positiv, aber oft auch nur einseitig. Eine eingehende neurologische Untersuchung wird fast immer noch weitere Symptome motorischer, sensibler oder reflektorischer Art zu Tage fördern. Hier sei besonders auf die einseitige Abschwächung des Achillesreflexes hingewiesen, die sehr häufig ist aber auch sehr leicht übersehen werden kann. In anderen Fällen finden sich so ausgeprägte segmentäre neurologische Symptome, dass daraus schon ein Hinweis auf die genauere Lokalisation gezogen werden kann. Bei den selteneren Bpr im Hals- oder Brustgebiet der Wirbelsäule sind die Symptome immer deutlicher und eigentliche neurologische Veränderungen fehlen wohl nie.

Grosse Bedeutung kommt der *Anamnese* zu. Der zeitliche Zusammenhang des Beginns des Leidens mit einem grösseren oder kleineren Trauma der Wirbelsäule wird in vielen Fällen angegeben. Besonders charakteristisch ist aber in der Anamnese das attackenweise Auftreten der Symptome, wobei in der Regel die ersten Attacken weniger schwer sind als spätere und manchmal auch die Häufigkeit der Attacken zunimmt. Während einer solchen Attacke sind die Schmerzen gegen jede konservative Behandlung refraktär, Ruhe und Wärme sind noch am ehesten in der Lage eine vorübergehende Besserung zu erzielen, doch ist auch das nicht von Dauer. Die Behandlung im Streckverband gibt während ihrer Dauer oft ganz gute Resultate, jedoch tritt sofort nachher wieder der vorherige Zustand ein. Gewöhnlich wird, da alle Therapie erfolglos war, zu starken analgetischen Mitteln gegriffen, die dem Patienten Linderung geben bis die Attacke wieder abklingt. Eine Zusammenstellung von Love über die anamnestischen Angaben und die objektiven Untersuchungsbefunde bei 88 Patienten, die mit positivem Befund operiert worden sind, ergibt folgende prozentuale Häufigkeit:

Es fand sich:	Kein Trauma	in	27 %	der	Fälle
	Attackenweise Symptome	»	86 %	»	»
	Kreuzschmerz früher als »Ischias»	»	58 %	»	»
	»Ischias»	»	92 %	»	»

Es fand sich:	Nur Kreuzschmerz	in	3 %	der	Fälle
	Nächtliche Schmerzen	»	31 %	»	»
	Verschlimmerung beim Husten etc.	»	39 %	»	»
	Paraesthesien	»	49 %	»	»
	Incontinenz der Sphinkteren	»	8 %	»	»
	Lassègue positiv	»	82 %	»	»
	Schmerzhaftigkeit des n. ischiad.	»	63 %	»	»
	Fehlender oder abgeschw. Achillerefl.	»	57 %	»	»
	Paresen	»	26 %	»	»
	Atrophie der Muskulatur	»	9 %	»	»
	Hypaesthesien	»	31 %	»	»
	Neg. klinische Untersuchungsresultate	»	3 %	»	»
	Neg. klinische Untersuchungsresultate bis auf pos. Lassègue	»	16 %	»	»

Die Untersuchung des liquor cerebrospinalis ist in allen Fällen, bei denen der Verdacht auf einen Bpr besteht, durchzuführen. Eine Erhöhung des Totaleiweissgehaltes über 40 mg pro 100 ccm wird bei Bpr sehr häufig gefunden, jedoch kommen auch Fälle vor mit normalem Eiweissgehalt des Liquor, dies besonders wenn der Pr unterhalb der Liquorpunktionsstelle liegt. Es darf aber die Liquoruntersuchung trotzdem nie unterlassen werden, um nicht anderweitige Veränderungen des Liquor zu übersehen. Um die Durchgängigkeit des Subarachnoidalraumes zu prüfen, ist in allen Fällen der QUECKENSTEDT zu kontrollieren und in allen Fällen mit Verdacht auf einen Bpr in der Lumbalgegend auch der sog. umgekehrte Queckenstedt[1] (LOVE).

Anatomisch handelt es sich beim Bpr um ein Hervortreten eines Stückes des annulus fibrosus der Zwischenwirbelscheibe, das ganz oder teilweise vom Rest der Bandscheibe abgerissen ist. Der nucleus pulposus quillt dahinter ebenfalls etwas vor, das komprimierende Stück besteht aber grössten Teils aus Annulus-Gewebe. Die bei der Operation entfernten Gewebsstücke zeigen alle mehr oder weniger starke Veränderungen struktureller Natur, daneben kommt starke Degeneration und auch Fibrose vor, (DEUCHER). In 22 Fällen, die während einer Attacke von Schmerzen operiert worden waren, fand sich ausserdem ein starkes Ödem des prolabierten Teiles der Bandscheibe. Dieses Ödem muss in einem Teil der Fälle als Ursache des attackenweisen Auftretens von Symptomen angesehen werden; wenn infolge Ruhigstellung oder Lageverschiebung des Bandscheiben-Fragmentes die ödematöse Schwellung wieder zurückgeht klingen auch die Schmerzen wieder ab (DEUCHER).

[1] Als Queckenstedt'sches Zeichen wird das Ansteigen des Liquordruckes bei Kompression der Jugularvenen bezeichnet, beim umgekehrten Queckenstedt steigt der Liquordruck an, wenn durch den Hiatus sacralis ca. 40 ccm einer NaCl Lösung epidural injiziert werden.

Eine v. d. und seitliche *Roentgenaufnahme* der Wirbelsäule muss in jedem auf Bpr verdächtigen Falle gemacht werden, sie gestattet allerdings keine Diagnose eines Bpr, jedoch wird man gelegentlich andere Processe der Wirbelsäule, die zu Kompression des Duralsackes führen können, entdecken. Die Verschmälerung des Abstandes der beiden Wirbel an der betroffenen Bandscheibe ist ein Zeichen, das — so einleuchtend es ist — mit allergrösster Vorsicht zu bewerten ist. Bandscheibenverschmälerungen infolge Degeneration der Scheibe sind ein sehr häufiges Vorkommnis; besonders häufig ist die Degeneration der 5. Lendenbandscheibe, hier sind aber auch die Bpr sehr häufig, so dass ein Zusammenhang in vielen Fällen wohl möglich ist. Die Untersuchungen von CAMP haben gezeigt, dass Bandscheibenverschmälerungen auch sehr häufig an Bandscheiben vorkommen, die keinen Prolaps haben, während beim selben Patienten eine andere normal hohe Bandscheibe einen grossen Prolaps aufweist. Immerhin kommt der Bandscheibenverschmälerung besonders wenn sie einseitig auf der Seite der stärkeren Symptome und auf der richtigen Höhe ist, eine gewisse diagnostische Bedeutung zu.

Ist auf Grund der obenerwähnten Untersuchungen der *Verdacht* auf einen das Rückenmark oder die Nervenwurzeln komprimierenden Process mit grosser Wahrscheinlichkeit auszusprechen, so muss zur definitiven Abklärung der Diagnose und zur genauen Lokalisation des Processes die *Myelographie* herangezogen werden. Da es sich bei den Bpr in der grossen Mehrzahl der Fälle nicht um einen den Wirbelkanal vollständig verlegenden Process handelt, ist die Myelographie nach SICCARD zur Feststellung eines Stops ungenügend. Die myelographische Diagnose eines Bpr stützt sich in erster Linie auf den *Durchleuchtungsbefund*, der dann durch geeignete, ebenfalls unter Durchleuchtungskontrolle vorzunehmende Aufnahmen festgehalten werden kann.

Technik der *Myeloscopie:* Am besten ist ein sowohl caudal wie cranial bis zu 45 Grad neigbarer Durchleuchtungstisch, auf dem zugleich auch Serienaufnahmen in jeder Lage gemacht werden können. Dies wird in der Regel nicht der Fall sein, die meisten Durchleuchtungstische sind nur an einem Ende neigbar. Der Patient muss dann so gelagert werden, dass einmal das Kopfende und dann das Fussende am kippbaren Teil des Tisches liegt. Zur Fixierung des Patienten ist eine Schulterstütze anzubringen, die genügend gepolstert ist, so dass der Pat. auch während mehrerer Minuten in steiler Kopftieflage belassen werden kann; ausserdem muss der Pat. auch in Schräg- und Seitenlagen durch die Schulterstütze fixiert sein (siehe Bild 1). Ist am Durchleuchtungstisch keine Serienaufnahmeapparatur vorhanden, so können Aufnahmen auch unter direktem Auflegen der Platte auf den Pat. bei Verwendung einer starren Buckyblende gemacht werden.

Abb. 1. Durchleuchtungs- und Aufnahmetisch mit Schulterstütze.

Nachdem 5 ccm Lipiodol durch Lumbalpunktion in den Subarachnoidalraum injiciert worden sind, wird der Patient ins Durchleuchtungszimmer gebracht. Hier lässt man ihn während ein bis zwei Minuten auf dem horizontalgestellten Durchleuchtungstisch sitzen um das ganze Lipiodol sich im caudalen Ende des Duralsackes ansammeln zu lassen. Hierauf legt man den Pat. in *Bauchlage* auf den horizontalen Tisch (oder wenn dieser beidseitig neigbar ist auf den mit dem Fussende um 45 Grad geneigten Tisch) in der Art, dass das Kopfende auf der neigbaren Seite sich befindet; hierauf wird die Schulterstütze fixiert.

Bei der Durchleuchtung überzeugt man sich zuerst, ob alles Lipiodol in einem Tropfen im unteren Teil des Duralsackes angesammelt ist. Bei Horizontal-Lage des Patienten befindet sich das Öl ungefähr auf Höhe von L 5 bis L 3; bei Fusstieflage im Sacralteil der Wirbelsäule hat das Depot dort eine charakteristische konische Form (Bild 2 und Bild 4). Hierauf orientiert man sich rasch über die Zahl der Lendenwirbel des Patienten um spätere Fehlbezeichnungen zu vermeiden. Durch Heben des Fussendes des Tisches wird der Anstieg des Lipiodols eingeleitet. In Horizontal-Lage hat das Öl die tiefste Stelle der Lumballordose erreicht und zum weiteren Anstieg muss nun der Kopf des Pat. nach unten geneigt werden. Durch verschieden starke Neigung des Tisches reguliert man die Geschwindigkeit der Ölbewegung, so dass die Säule immer genau beobachtet werden kann, und dass sie nicht zu stark in die Länge zieht, da sonst die Gefahr besteht, dass einzelne Tropfen sich loslösen. Der Conus terminalis führt häufig zu einer vorübergehenden Hemmung des Anstieges, die aber durch stärkere Neigung des Tisches leicht überwunden wird; eine zweite Verzögerung tritt gewöhnlich auf Höhe von Th 10 bis Th 9 auf infolge der Thoracalkyphose. Hat das Öl das obere Halsmark erreicht, so wird durch Absenken des Fussendes des Tisches die rückläufige Bewegung eingeleitet, ist das Öl in der unteren Lendengegend angelangt, so muss der Tisch mit dem Fussende stark nach unten geneigt werden, damit die Sacralkrümmung kompensiert wird, zu diesem Zwecke muss der Pat. auf dem nur einseitig neigbaren Tisch umgelagert werden, was am besten als Abschluss der Untersuchung geschieht. Wurde ein Defekt festgestellt, so ist die Untersuchung in *Bauchschräglage* und in *Seitenlage* zu wiederholen, aber auch bei

negativem Befund empfiehlt sich dies. Hierauf lässt man den Pat. wieder für eine Minute aufsitzen und wiederholt die Untersuchung in *Rückenlage*. Da Bpr den Duralsack von vorne her komprimieren, wird sich ein so verursachter Defekt in Rückenlage meist nicht mehr nachweisen lassen (siehe Bild 8).

Während bei der Durchleuchtung nur der grobe Schattenumriss des Lipiodols erkannt werden kann, sind auf den Aufnahmen noch weitere wichtige Details zu erkennen. Als solche kommen in erster Linie *Aussparungen* im Lipiodolschatten, die durch die austretenden Nervenwurzeln verursacht werden, sowie die durch kleine Kontrastmittelansammlungen in den Nervenscheiden sich darstellenden *Ausbuchtungen* des Duralsackes in Betracht. In Bild 2 und 3 sind diese normalen Verhältnisse deutlich zu erkennen. Auf Grund eingehender Studien hat HAMPTON die Röntgenbefunde mit den anatomischen Tatsachen in Einklang gebracht. Wir sehen in Bild 2 die austretenden 5. Lenden- sowie die 1., 2. und 3. Sacralnervenpaare entlang ihren Nervenscheiden mit feinen Kontrastansammlungen wie ausgezeichnet. In den Nervenscheiden von L 4 sind ebenfalls kleine Kontrastdepots zurückgeblieben, trotzdem die Hauptmasse des Öls sich weiter unten befindet. Diese Aufnahme ist in Fusstieflage gemacht, das Öl hat sich deshalb im untersten Abschnitt des Duralsackes angesammelt und auch in den Nervenscheiden hat das schwerere Öl die unteren Partien gefüllt während der austretende Nerv gewissermassen auf dem Kontrast schwimmt; er kann, wenn man dies berücksichtigt, überall in seinem Verlauf genau verfolgt werden und innerhalb des eigentlichen Duralsackes ist der austretende Nerv der cauda equina als eine bandförmige Aufhellung in der Hauptmasse des Lipiodolschattens deutlich erkennbar, besonders bei L 5 (Vergleiche Skizze 3 in der die Nerven punktiert eingezeichnet sind). Die Nerven werden nach dem Wirbel bezeichnet, auf dessen Höhe sie durch das foramen intervertebrale austreten, sie sind aber durch die Aufhellung schon viel weiter oben erkennbar, wie sie sich aus den übrigen Fasern der cauda equina lösen und von da bis zur eigentlichen Austrittstelle die seitliche Begrenzung des Kontrastschattens, der infolgedessen eine leicht bogenförmige Gestalt annimmt, bilden. Bild 4 zeigt die normalen Verhältnisse bei Horizontal-Lage des Pat. Entsprechend der Lumballordose liegt das Öl nun auf Höhe von ca L 3 bis L 4, der Öltropfen erscheint wesentlich grösser als in Bild 2, da der Duralsack im untersten Abschnitt relativ viel weiter ist und so ein haufenweises Ansammeln des Öles ermöglicht, während auf Höhe von L 4 und noch weiter oben der vom Öl einnehmbare Subarachnoidalraum schon wesentlich enger ist. Diese Tatsache ist für die Beurteilung von Defekten äusserst wichtig, da im untersten Abschnitt kleine Defekte sehr leicht übersehen werden können und auch grosse Prolapse oft unverhältnis-

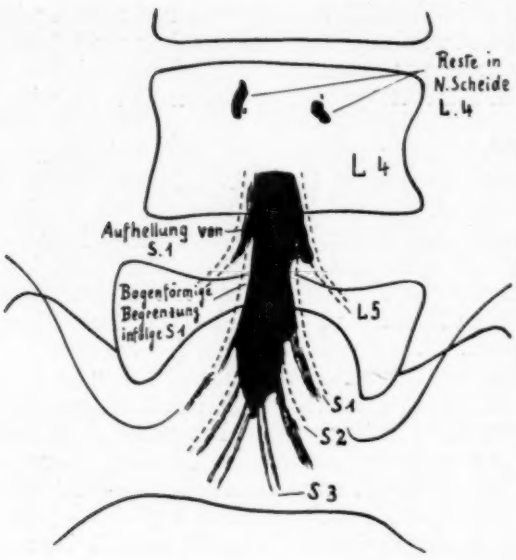

Abb. 3. Schematische Skizze zu Röntgenbild 2. Punktiert = Nervenverlauf.

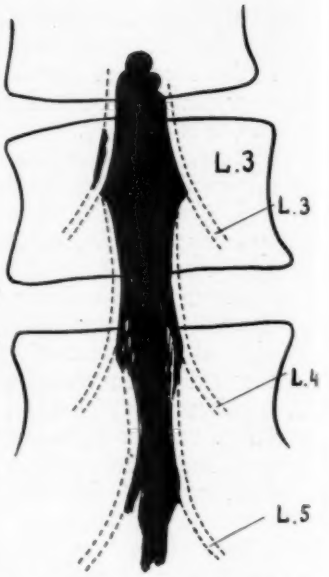

Abb. 5. Skizze zu Röntgenbild 4.

mässig kleine Defekte hervorrufen. Je weiter wir nach oben kommen, desto deutlicher stellen sich auch kleinere Defekte dar. So ergibt sich, dass die Beurteilung einer kleinen Impression im untersten Teil des Duralsackes eine ganz andere sein muss als höher oben. (Bild 16)[1]. Da die meisten Prolapse die Bandscheiben L5/S1 und L4/L5 betreffen, ist die genaue Kenntnis dieser Verhältnisse unerlässlich für eine genaue Diagnose. Auch auf Bild 4 sind die austretenden Nervenstämme an den bandformigen Aufhellungen und den kleinen seitlichen Zacken des Öltropfens erkenntlich, diese Zacken entsprechen den unteren Teilen der Nervenscheiden, die sich mit Kontrast gefüllt haben, jedoch hier nur auf eine kürzere Strecke als in den unteren Nervenscheiden (Bild 2). Der austretende Nerv liegt jeweils wieder oberhalb davon, siehe Skizze 5.

Im Bereich oberhalb des conus wird der von Öl zu füllende Teil des Subarachnoidalraumes wesentlich enger, der Öltropfen zieht sich hier deshalb noch mehr in die Länge und vorübergehende Verzögerungen in der Ölbewegung sind keine Seltenheit. Sie beruhen teils auf der verschiedenen Neigung des Wirbelkanals infolge der normalen Krümmung

[1] Dieser Fall wurde bis jetzt noch nicht operiert, es wird deshalb auf ihn nicht näher eingegangen.

Abb. 2. Abb. 4.

Abb. 2. Normale Füllung des caudalen Endes des Duralsackes mit den austretenden Nervenstämmen (vergl. Skizze 3).

Abb. 4. Normale Füllung des lumbalen Teiles des Duralsackes in horizontaler Bauchlage (vergl. Skizze 5).

Abb. 8. Seitenaufnahme in Rückenlage (nur 2 ccm Lipiodol). Gleicher Fall wie Abb. 6. Der Defekt ist nicht zu sehen, da das Öl dorsal liegt.

Abb. 8.

der Wirbelsäule, teils auf den normalen Engen und Weiten des Markes und teils auch auf Hemmungen durch das ligamentum denticulatum. Hier ist genaueste fluoroscopische Beobachtung notwendig unter wechselnd starker Neigung des Tisches sowie Vergleich der verdächtigen Stellen beim Auf- und Abstieg des Kontrastmittels. Eine genaue Kenntnis der Stellen der normalen Verzögerung ist zur Beurteilung unerlässlich.

Da weitaus der grösste Teil aller Bpr die Lendenregion betreffen, sei hier vornehmlich auf die Befunde in diesem Gebiet eingegangen. In

Abb. 6.

Abb. 7.

Abb. 18.

Abb. 6. Einseitiger Prolaps von Bandscheibe L 2/3. Aufnahme v.-d. in Bauchlage des Patienten.
Abb. 7. Gleicher Fall wie 6 in Bauchschräglage des Patienten.
Abb. 18. Zwei Bandscheibenprolapse an L 3/4 und L 4/5 aus Mayo Clinic (CAMP).

der Brust- und Halsregion finden sich die selben Bilder unter Berücksichtigung der weiter oben erwähnten Modifikationen. *Der hintere Prolaps einer Bandscheibe präsentiert sich bei der Myelographie wie ein extraduraler Tumor.* Es findet sich ein *abgerundeter Defekt*, der zahnförmig in den den Subarachnoidalraum füllenden Schatten des Lipiodol hereinragt und dadurch die Breite des Schattens an dieser Stelle stark verschmälert. Der Defekt ist *allseits scharf begrenzt*, er ist meist einseitig, kann aber häufig bis über die Mittellinie hinaus reichen (siehe Bild 6 und 7); seltener sind beidseitige Defekte. Der Defekt liegt auf *Höhe* der *Zwischenwirbelscheibe*, seine Breite entspricht ungefähr der Breite dieser Bandscheibe, an der Basis ist er allerdings häufig breiter, was

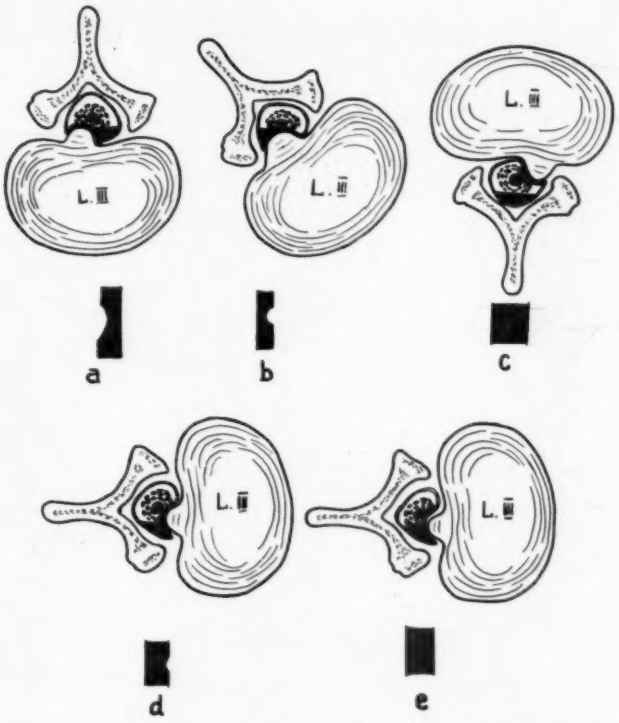

Abb. 9. Skizzen zur Lage des Lipiodols auf Höhe der 3. Lendenbandscheibe bei verschiedener Körperlage. Schemat. anatomische Querschnitte. Darunter ist das Myelographische Bild eines Defektes in der entsprechenden Lage eingezeichnet.
a = Patient in Bauchlage, b = in Bauch-Schräglage, c = in Rückenlage.
d = in Seitenlage, 1. Möglichkeit, e = in Seitenlage, 2. Möglichkeit.

darauf zurückzuführen ist, dass die Dura die zwischen dem Prolaps und der angrenzenden Wirbelkörperkante entstehende scharfe Ecke überbrückt. *Der durch einen Bpr hervorgerufene Defekt ist bei Untersuchung in Bauchlage und Bauchschräglage am deutlichsten, in Rückenlage ist er häufig nicht mehr sichtbar*, da das Öl nun nur noch die rückwärtigen Partien des Wirbelkanals ausfüllt (Bild 8); auch in Seitenlage ist der Defekt häufig nicht sichtbar, und wenn er sichtbar ist, ist er meist recht unbedeutend. Diese Tatsachen finden ihre Erklärung in der Form des Wirbelkanals und der durch die spezifische Schwere des Kontrastmittels gegebenen Niveaueinstellung desselben. In der Skizzenserie (Bild 9) sind die verschiedenen Möglichkeiten dargestellt.

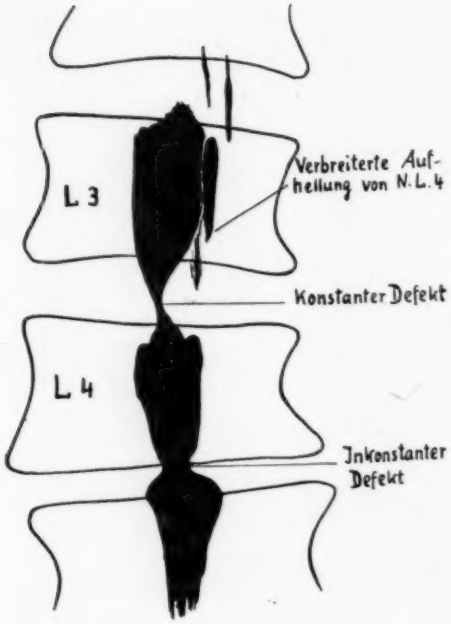

Abb. 11. Skizze zu Bild 10.

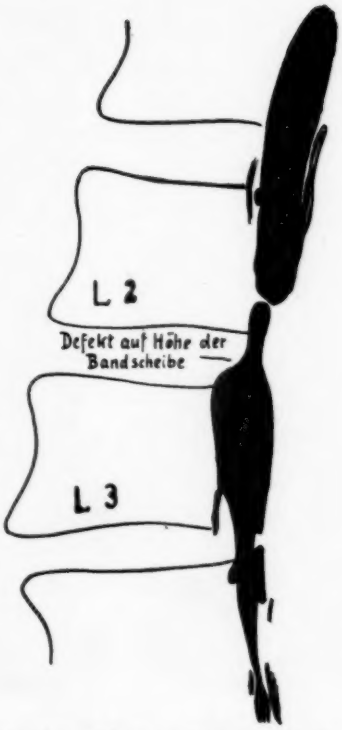

Abb. 14. Skizze zu Röntgenbild 13.

Hat man bei der Durchleuchtung einen verdächtigen Füllungsdefekt festgestellt, so gilt es vor allem nachzuweisen, ob es sich um einen *konstanten* oder vorübergehenden Befund handelt. Man muss deshalb unter Durchleuchtungskontrolle alles tun, um den Defekt zum Verschwinden zu bringen, und nur wenn dies nicht gelingt, weder beim Auf- noch beim Abstieg des Öls und auch nicht nach Umlagerung des Patienten oder bei schwächerer Neigung des Tisches oder bei wiederholter Untersuchung nach Tagen oder Wochen, darf ein Bpr diagnostiziert werden. Diese Forderung kann nicht genug betont werden, da vorübergehende Verschmälerungen des Öltropfens auf Höhe der Zwischenwirbelscheiben gar nicht selten sind und sich sogar durch unrichtiges Manipulieren des Patienten direkt hervorrufen lassen. Ein solcher *inkostanter Defekt* ist aber vollständig *bedeutungslos*, auch wenn er grosse Ähnlichkeit mit einem Bpr aufweist. Ausserdem muss der *Defekt* in

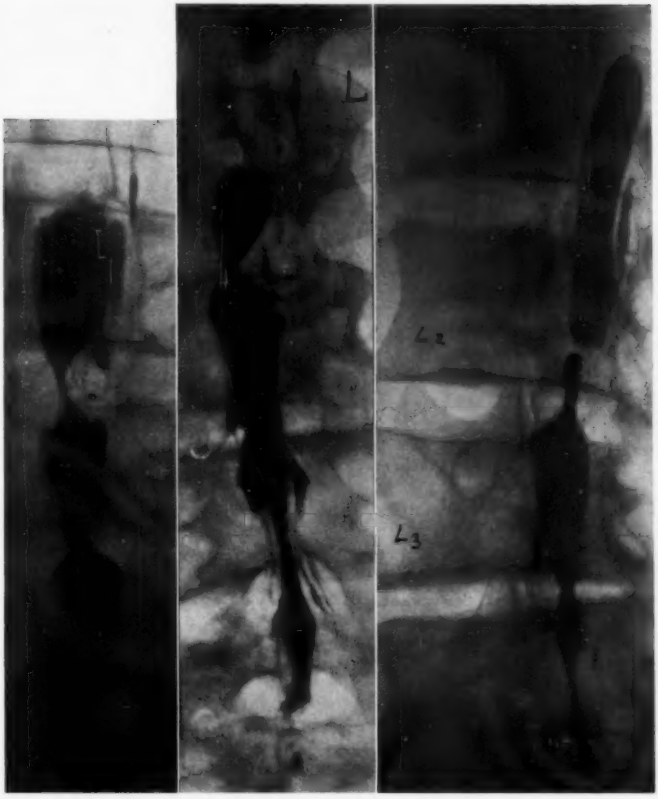

Abb. 10. Abb. 12. Abb. 13.

Abb. 10. Grosser Prolaps der Bandscheibe L 3/4. Unkonstanter Defekt bei L 4/5. Verbreiterung der Aufhellung der linken 4. Lumbalen Nervenwurzel und Verdrängung dieses Nerven nach lateral. (vergl. Skizze 11).

Abb. 12. Der »Defekt« bei L 4/5 ist nicht mehr zu sehen. Bei L 3/4 konstanter Defekt.

Abb. 13. Halbschrägaufnahme von Bild 10.

Bauchschräglage *vorne* liegen. Erst wenn die Konstanz eines Defektes festgestellt ist, rechtfertigt es sich Aufnahmenserien anzufertigen, Aufnahmen ohne Durchleuchtung beweisen nichts. (Bild 10 und 11 neg. Befund bei L 4) (HAFFNER, JAROSCHY).

Die Protrusion einer Bandscheibe komprimiert aber nicht nur den intraduralen Teil der cauda equina oder des Markes sondern es wird auch der austretende Nervenstamm dort komprimiert, wo er über den

Abb. 15.

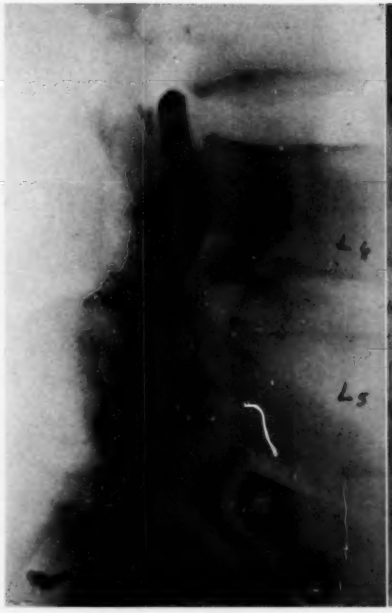

Abb. 16.

Abb. 17.

Abb. 15. V.-d. Aufnahme bei fast vollständigem Stop infolge Prolaps der Bandscheibe L 4/5.

Abb. 16. Seitenbild von 15 mit hinterem Kantenbruch am 4. Lendenwirbel.

Abb. 17. Flacher Defekt auf Höhe der Bandscheibe L 5/S 1. Nur in dieser Lokalisation als positiver Befund zu bewerten. (Der Pat. wurde noch nicht operiert).

Prolaps zieht. Hierdurch schwillt der oberhalb davon gelegene Teil ödematös an. Dieses Anschwellen kann sich im myelographischen Bild durch eine Verbreiterung der bandförmigen Aufhellung im Haupttropfen des Öles darstellen. Ausserdem ist der austretende Nerv oft nach lateral verlagert, während der die seitliche Begrenzung bildende nächstfolgende Nerv nach medial verlagert ist; hiedurch entsteht das Bild des erweiterten Abstandes der beiden aufeinander folgenden Nervenstämme, das wenn mit einem Defekt des Haupttropfens verbunden, äusserst charakteristisch ist (Bild 10 und 11). Bei sehr grossem Prolaps kann es auch zu einer vollständigen oder fast vollständigen Arretierung des Lipiodols kommen (Bild 13 und 14) (JEQUIER und ROSSIER).

Obschon das typische Bild eines Bandscheibenprolapses bei der Myelographie sehr charakteristisch ist und besonders bei gleichzeitiger Ver-

schmälerung der entsprechenden Bandscheibe häufig ganz eindeutige Bilder ergibt, können in anderen Fällen auch grosse differentialdiagnostische Schwierigkeiten auftreten, da ähnliche Bilder auch bei Arachnitis vorkommen. Hier kommt besonders der Durchleuchtung in Schräg- und Seitenlage oft eine entscheidende Bedeutung zu. Ausserdem sind arachnitische Taschen oft in grösserer Anzahl vorhanden und unregelmässig verteilt; auch haben sie beim Aufstieg des Öles manchmal eine andere Form als beim Abstieg. Trotzdem wird es aber immer Fälle geben, bei denen eine sichere myelographische Diagnose nicht möglich ist. Bei vollständigem Stop ist es ebenfalls auf Grund der Myeloskopie und Myelographie allein oft nicht möglich, einen Bpr zu diagnostizieren, wenn nicht wie im Bild 14 z. B. noch ein hinterer Kantenbruch des angrenzenden Wirbelkörpers diese Diagnose äusserst wahrscheinlich macht. Die in nahezu allen Fällen von längere Zeit bestehendem Bpr vorhandene Verdickung des ligamentum flavum (Love) kann sich unter Umständen auch bei der Myelographie bemerkbar machen, indem sich dann neben dem Defekt an der Vorderseite noch eine Impression an der Hinterseite findet; diese kommt am besten in Schräg- oder Seitenlage zur Darstellung (Camp). Solche Fälle dürfen nicht mit ringförmigen Tumoren verwechselt werden. Die blosse Hypertrophie des hinteren Randes der Bandscheibe ohne Ruptur des annulus kann, wenn sie hohe Grade erreicht, das Bild eines Prolapses hervorrufen, und es ist dann fast unmöglich die richtige Diagnose zu stellen, besonders wenn noch dazu die entsprechende Bandscheibe verschmälert ist. Die Hypertrophie des hinteren Bandscheibenrandes führt meist zu beidseitigen Defekten und ist vielfach an mehreren Bandscheiben vorhanden, jedoch sind auch multiple Prolapse keine Seltenheit. (Bild 18[1]).

Es sollen nun noch kurz drei Krankengeschichten von typischen Fällen, deren Bilder hier veröffentlicht wurden, wiedergegeben werden.

Fall 1. 39jährige Schneiderin. Vor 10 Jahren Sturz von der Treppe auf den Rücken; seither Schmerzen im Rücken, wie ein Zwick. Attackenweise Verschlimmerung meist nach besonderer Beanspruchung des Rückens. Dauer jeder Attacke immer mehrere Wochen bis Monate. Dauernd in ärztlicher Behandlung mit Antirheumatica und Bäderkuren ohne Erfolg. Entfernung einer verkalkten abdominellen Lymphdrüse im Jahre 1936 und anschliessend Höhenaufenthalt ohne Erfolg. Myelographie nach Methode Siccard 1936 mit neg. Ergebnis (Bild 8). Da neben den Rückenschmerzen mit Ausstrahlung in beide Beine besonders das linke, noch psychische Depressionen bestehen, werden die Beschwerden als weitgehend psychogen angesehen und ein Sanatoriumsaufenthalt von 6 Monaten durchgeführt, wonach die Depressionen gebessert sind, die Rückenschmerzen aber nicht. Im Jahre 1939 wieder Behandlung mit physikalischer Therapie ohne Erfolg. Seit Beginn des Leidens hat sich dieses dauernd verschlechtert,

[1] Diesen Fall mit Bpr von L 3/4 und L 4/5 sah ich während meiner Tätigkeit an der Mayo Clinic Rochester Minn. und ich möchte Dr. Kirklin und Dr. Camp für die Einwilligung zur Reproduktion des Bildes an dieser Stelle bestens danken.

Pat. kann jetzt nicht mehr sitzen und nur mit grossen Schmerzen an Stöcken gehen, Treppenheruntergehen, Husten, Niesen, Rückwärtsbeugen des Oberkörpers und Heben von Gegenständen verursacht starke Verschlimmerung der Schmerzen.

Im August 1939 wird Myeloskopie durchgeführt und die Myelographie mit neuer Technik wiederholt. Es werden vorerst die vor 3 Jahren injicierten 2 ccm Lipiodol nochmals verwendet. Es lässt sich ein konstanter Füllungsdefekt auf Höhe der Bandscheibe L 3/L 4 feststellen. Zur Darstellung des Defektes in toto werden noch ca 3 ccm Lipiodol injiciert; sie vermischen sich anstandslos mit dem alten Lipiodol und bilden eine einheitliche Masse; ein typischer Defekt ist so sichtbar (Bild 6 und 7).

Bei der klin. Untersuchung fand sich beidseits ein positiver Lassègue, sowie Schmerzhaftigkeit der nervi ischiadici bei Druck, die Dornfortsätze sämtlicher Wirbel sind klopfempfindlich, im Übrigen sind die Befunde negativ, die Reflexe sind normal. Liquor-Zellgehalt nicht erhöht, Totaleiweiss 22 mg %. Queckenstedt und umgekehrter Queckenstedt zeigt Durchgängigkeit des Liquorraumes.

Am 5. 8. 39 Operation in Privatklinik. (Prof. VERAGUTH) Laminectomie und Entfernung eines Bandscheibenprolapses der 3. Lendenbandscheibe.

Guter postoperativer Verlauf. 4 Wochen nach der Operation kann Pat. wieder sitzen ohne Schmerzen.

Fall 2. 42 j. Elektriker 1922 erster Ischias-anfall, nächster Anfall im Jahre 1928, links stärker als rechts, seit da nie ganz schmerzfrei, starker Anfall im Jahre 1936 und dann wieder 1939 jetzt in beiden Beinen, links stärker als rechts. Die Schmerzen sind am stärksten beim Bücken und beim Aufstehen vom Sitzen, sie verstärken sich beim Husten und Niesen.

Die klin. Untersuchung ergibt eine Hyposensibilität im Ausbreitungsgebiet des Nerven L 2 und abwärts davon, Lassègue ist beidseits schwach positiv, Reflexe bis auf Abschwächung der BDR links normal, Klopfempfindlichkeit der Wirbelsäule auf Höhe von L 2. Liquor: Druck 200, Totaleiweiss 22 mg %, Kolloidreaktionen: leichte organische Zacke. Queckenstedt und umgekehrter Q. neg.

Myelogramm Defekt auf Höhe der Bandscheibe L 2/L 3. (Bild 10).

Operation am 18. 9. 39 (KRAYENBÜHL) Laminectomie und Entfernung eines 2 gr. schweren Bandscheibenprolapses von L 2.

Am 28. 9. 39 ist der Patient vollständig beschwerdefrei.

Fall 3. 39 j. Bahnarbeiter. Am 19. 4. 38 Sturz auf Rücken, sofort darauf starke Schmerzen in der Kreuzgegend, diese Schmerzen dauern an, sie verstärken sich beim Heben von Lasten und beim Rückwärtsbeugen. Seit Dezember 1938 auch ischiasartige Schmerzen. Im Januar 1939 wieder Verschlimmerung der Kreuz- und Ischias-Schmerzen, die Ischias ist links stärker als rechts. Jetzt auch zum ersten Mal das Gefühl von Unempfindlichkeit im rechten Bein.

Die klin. Untersuchung ergibt Hyposensibilität von S 2 an abwärts, Reflexe normal bis auf eine Abschwächung des Plantarreflexes links, Lassègue bds pos. Liquor: Totaleiweiss 176 mg%. Kolloidalreaktionen: Kurven schwach meningealer Typ.

Myelogramm: Fast vollständiger Stop auf Höhe von L 4 und hinterer Kantenbruch von L 4. (Bild 13 und 14).

Am 7. 4. 38 Operation (ZEHNDER) Laminectomie und Entfernung eines Bandscheibenprolapses von L 4.

Am 14. 8. 39 bei Kontrolluntersuchung war Pat. beschwerdefrei.

Zum Schluss sei noch kurz auf die Frage der Indikation zur Myeloskopie und Myelographie und der Schädigung durch die Lipiodolinjektion eingegangen. Es wurde schon zu Beginn erwähnt, dass nach unserer Ansicht nur Fälle der Myelographie zugeführt werden sollen, bei denen auf Grund der klinischen Untersuchung ein hoher Wahrscheinlichkeitsgrad für das Vorliegen eines positiven Befundes spricht, da bei der Laminectomie ein grosser Teil des Lipiodols wieder entfernt werden kann, während es sonst während Jahren liegen bleibt. Die von DANDY ursprünglich angegebene Myelographie mit Luft als Kontrastmittel, die jetzt von verschiedenen Autoren wieder in modifizierter Form aufgenommen wird (CAMP, LINDGREN und andere) gibt vorläufig noch nicht in allen Fällen die erhofften eindeutigen Resultate. Dass das Lipiodol auf die Meningen reizend wirkt, steht fest, jedoch ist das Mass dieser Reizung von Fall zu Fall sehr verschieden. Die direkten Folgen der Lipiodolinjektion, die sich durch eine Verstärkung der bestehenden Schmerzen äussern, klingen fast immer innerhalb einer bis zwei Wochen ab, wonach für den Patienten der frühere Zustand wieder erreicht ist. Die objektiven Veränderungen, die in einer oft sehr starken Steigerung des Zellgehaltes des Liquors bestehen, sinken ebenfalls innerhalb wenigen Tagen wieder ab, jedoch bleibt auch nach Jahren noch eine gewisse Zellvermehrung bestehen (WALSH). Da das nicht resorbierbare Lipiodol im Liquor nur als Fremdkörper wirkt, ist es höchst unwahrscheinlich, dass 4—5 ccm eine andere Wirkung hervorrufen als bloss 2 ccm. Auch alle in der Literatur vorhandenen Arbeiten über diese Frage entsprechen dem oben gesagten, es werden gelegentlich nach Lipiodolinjektion besonders starke Reaktionen beobachtet, jedoch sind diese bei Injektion von 5 ccm keineswegs häufiger als bei 2 ccm. Unser Fall 1 bei dem vor drei Jahren eine Myelographie mit 2 ccm durchgeführt wurde, zeigte bei der Operation eine Verdickung und Injektion der Arachnoidea. Da auch nach Injektion von nur 2 ccm gewisse Veränderungen auftreten können, erscheint es uns nicht gerechtfertigt die Unsicherheit der 2 ccm Methode gegen die viel grössere Sicherheit der Untersuchung mit 4—5 ccm einzutauschen, ganz besonders nicht für die Beurteilung der unteren Lendenregion, aus der blossen, noch in keinem Falle bewiesenen Vermutung heraus, dass 5 ccm mehr schaden als 2 ccm (GLORIEUX, SCHUELLER, WALSH). Wir müssen hoffen, dass wir in absehbarer Zeit in der Lage sein werden die Myelographie mit einem nicht reizenden Stoff, der resorbierbar ist, durchzuführen, so dass dann die Indikation zur Myelographie wesentlich weiter gesteckt werden kann und viele Patienten, deren Leiden heute noch unerkannt bleibt, weil ihre Symptome zu wenig eindeutig sind, der für sie einzig möglichen Heilung, nämlich der *Laminectomie* und *Entfernung* des *Prolapses*, zugeführt werden können.

ZUSAMMENFASSUNG

Der Verfasser bespricht die klinischen Symptome und die anatomischen Grundlagen der hinteren Bandscheibenprolapse, die zu Kompression des Rückenmarkes oder der austretenden Nervenstämme führen. Eine sichere Diagnose dieser Krankheit ist aber nur vermittels der Röntgenkontrastuntersuchung des Wirbelkanals zu stellen. Nach lumbaler Injektion von 5 ccm Lipiodol wird die Myeloscopie am neigbaren Durchleuchtungstisch durchgeführt. Bandscheibenprolapse können in der Regel nur in Bauchlage oder in Bauchschräglage erkannt werden, sie präsentieren sich dann wie ein extraduraler Tumor auf Höhe einer Zwischenwirbelscheibe. Auf Röntgenbildern kann neben diesem Befund häufig noch die ödematöse Schwellung eines austretenden Nervenstammes an der Verbreiterung der entsprechenden Aufhellung im Lipiodoltropfen erkannt werden. Ein Defekt in der Lipiodolsäule ist nur von Bedeutung, wenn er konstant ist. Aus diesem Grunde ist die Myeloscopie von ausschlaggebender Bedeutung.

3 typische Fälle, die im Laufe des Frühsommers 1939 am Zürcher Universitätsröntgeninstitut diagnostiziert wurden, werden kurz geschildert. Alle drei Fälle sind mit Erfolg operiert worden.

SUMMARY

The author discusses the clinical symptoms and the anatomic condition of posterior protrusions of the intervertebral discs compressing the spinal cord or the nerve roots. The roentgen examination of the spinal canal by the mean of a contrast medium serves to establish the diagnosis of this disease. After lumbar injection of 5 ccm of lipiodol the examination is done on a tilting fluoroscopic table; with the patient in the prone or the prone-oblique position a protruded disc will show as an extradural tumor at the level of the intervertebral disc. Myelographic pictures will frequently show the swelling of a nerve root by a broadening of the negative shadow of this root. Only a constant defect in the column of lipiodol is significant. Therefore utmost importance must be attributed to the myeloscopic findings.

The case histories of three cases diagnosed during early summer 1939 at the Department of radiology of the University of Zuerich are reported; all three cases have been operated on successfully.

RÉSUMÉ

L'auteur entre dans la discussion des symptômes cliniques et des fondements anatomiques du prolapsus dorsal des disques intervertébraux, qui a pour conséquence une compression de la moelle épinière et des racines efférentes. Le diagnostic certain de cette lésion pose comme condition nécessaire l'examen radiographique avec injection lombaire d'un liquide contrastant. L'injection d'une dose de 5 cm^3 de Lipiodol et une inclinaison convenable du corps rend possible la myéloscopie. Le prolapsus des disques intervertébraux ne se révèle généralement que si le malade est allongé sur le ventre ou occupe une position légèrement oblique. Il apparaît alors sous la forme d'une excroissance extradurale au niveau d'un disque intervertébral. Le radiogramme peut en outre, par l'importance d'une raréfaction des gouttelettes de Lipiodol révéler l'existence d'une infiltration œdémateuse dans une racine efférente. Une altération insolite de la colonne de Lipiodol n'aura de sens que si elle se répète de façon constante; considération prise de ce qui précède, la myéloscopie permet de se prononcer décisivement. Trois cas, types qui ont fait l'objet d'un radio-diagnostic au cours de l'été 1939 à l'Institut radiographique de l'Université de Zürich sont ensuite décrits. Tous trois ont été opérés avec succès.

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FROM THE ROENTGEN CLINIC OF THE STATE HOSPITAL, COPENHAGEN, DENMARK
(CHIEF: PROF. P. FLEMMING MØLLER, M. D.)

ON COMPARISON BETWEEN THE ROENTGENOLOGIC AND THE OPERATIVE FINDINGS IN ACUTE, MECHANICAL ILEUS[1]

by

Svend A. Chrom, M. D.

I shall limit myself to a consideration of the information to be obtained by roentgen examination of an ileus case compared with the corresponding operative findings. For the same reason, I also confine myself to such cases in which the operation has taken place in more or less direct relation to the examination by roentgen. Subiliac cases and cases of paralytic ileus of various etiology are, consequently, not included in the following report.

When it is a question of evaluating roentgenographs taken without contrast substance, of an abdomen with gas-filled intestines, certain things must be clearly understood beforehand, if there is to be any possibility of arriving at a correct result. Firstly, it must be determined in what portion of the intestine the gas is present and whether the accumulation is greater than what one might expect to find in that portion under normal conditions; and if the latter is the case it must be examined whether there is any fluid level visible in the film taken with the patient in the upright position. Next, it must be decided whether, in the case under consideration, there is any possibility that injection of a contrast enema may yield further information (which decision must, of course, be made with due regard for the fact that these patients are often in a low state); and finally comes the evaluation of the result of the injection.

The idea is now, on the basis of a comparison of the roentgen evidence and the operative findings, to try to find out with what degree of certainty it can be determined whether existing distended loops belong to the large or the small intestine; whether an ileus of the latter is high

[1] Read before the Meeting of the Northern Association for Medical Radiology in Oslo, June, 1939; submitted for publication Nov. 17, 1939.

or low; whether a fluid level can be demonstrated in the roentgenographs in all cases where operation has been performed and a mechanical ileus found to be present; whether a roentgenologically visualised colonic obstruction corresponds to the condition disclosed by the subsequent operation; and whether it is often possible from the roentgenologic picture to deduce anything in regard to that obstruction.

My material is from the State Hospital in Copenhagen. It comprises 52 cases, of patients in ages from 19 to 74 years, 15 male and 17 female, all admitted during the years 1935 to 1938 inclusive. All the operations were performed in the State Hospital, surgical Dep't D; 3 of the cases did not come to operation, but the necropsy later furnished information that could be used. In 19 cases the roentgen examination took place shortly before the operation, that is within about 1 hour before the abdomen was opened; in the others from 4 hours to 13 days before.

To determine whether a gas accumulation with dilatation is in the large or small intestine, one first notes the situation of the distended loops in the abdomen; but this criterion is uncertain; the absolute lies in whether there is haustration of the loops or not. In regard to the 19 cases that were examined within an hour before the operation, — and these are the only ones that can be considered in this connexion, — the following shows how far the operative findings bore out the roentgen diagnosis on this point.

In 16 of these 19 cases the operative findings agreed completely with the roentgenologic; the roentgen examination having shown gaseous dilatation of the small intestine alone in 8 cases, of the colon alone in 5, and of both portions in 3 cases. In the 3 remaining cases the findings did not agree. In two of these the operation disclosed gaseous dilatation in portions of the intestine where there had been no roentgen evidence of such. In one of them, where the roentgenographs had shown largely distended loops of small intestine, while it was not believed that there was any gas accumulation in the colonic portion, the operation showed moderate distention of the cecum. The patient in this case had a paralytic ileus following an appendicitis with perforation, where presumably a further development of gas may have occurred, or the gas already present have become differently distributed, even in the short interval from the roentgen examination to the operation. In the other case there was no roentgen evidence of gaseous dilatation in any part of the intestine; but the operation, for which there was indication in marked clinical symptoms of ileus, showed moderately distended and inflamed loops of small intestine, with distinct mark after parietal incarceration over an area about 2.5 cm. in diameter. In the third case in which the operative findings did not correspond with the roentgenologic, the films, on the contrary, suggested more than was actually found, since they seemed to

show distended loops both of small and large intestine, while on operation only immensely distended loops of the latter were found. I shall come back to this case in the following, in another connexion.

From a consideration of this material it must thus, on the whole, be said that there is possibility of getting reliable information in regard to the location of an existing gaseous dilatation in the two portions of the intestine by radiography of the abdomen without the use of contrast substance.

An important criterion for the determination of whether a state of ileus exists or not are the »fluid levels» first described by KLOIBER. To get a better idea of the value of this indicium I have made a survey of the 18 cases of verified ileus of the small intestine which were operated upon, and have found distinct fluid levels in 16 of them, while in 2 cases with gaseous dilatation of the small intestine none could be demonstrated in the roentgenographs taken with the patient in the upright position. In one of these cases, between 1 and 2 days had elapsed from the time when the symptoms first declared themselves to the time the roentgen examination took place; in the other about 24 hours. The interval between the roentgen examination and the operation was in the first case fully twenty-four hours, in the others about 1 hour. It may be noted that both patients had had repeated attacks of vomiting. At operation, strangulated ileus with constriction of the small intestine was found.

Also in 6 of the cases with fluid level the roentgen examination took place within 1 to 2 days from the onset of the symptoms. The number and size of the fluid levels varied considerably. In the other 10 cases the symptoms had been present from two to twenty-one days before the patients were roentgenographed. Also in this group there is great variety in the pictures of the fluid levels. They are present in the great majority of cases of operatively verified ileus of the small intestine, but can be absent in the cases where the patient comes to roentgen examination a relatively short time after the onset of the symptoms.

A survey of the cases of ileus of the large intestine, 12 in all, with reference to the presence of fluid levels, shows that the latter is found in 11, while the twelfth was not roentgenographed in the upright position or with horizontal ray projection, and can therefore not be considered in this connexion.

The time from the onset of the symptoms to the roentgen examination varied from 24 hours to 10 days. Also the number and size of the fluid levels varied immensely, apparently without the slightest regularity. In contrast to what was the case in the small-intestinal group, fluid levels were in this group of large-intestinal cases demonstrated in all the patients examined with that object in view. It is difficult, however, to say whether this difference between the two groups may not be merely

accidental, due to the small number of cases on which the comparison is based.

For the surgeon it will always be of great importance to be able to get information concerning the causes responsible for the occurrence of an ileus. If the case is one of mechanical ileus, the roentgenologist will immediately be asked whether anything precise can be said about the nature and location of the obstruction. Among my material of small intestinal ileus there is only one case in which it was possible in the roentgenographs taken without contrast injection to see a linear obstruction in the intestine, which might be supposed to indicate a strangulation. The operation disclosed an adhesion at a point which would correspond very well to this line in the roentgenograph. The criteria for whether an ileus of the small intestine is high or low are so few and uncertain that opinion in that respect can be expressed only with the greatest reservation. It is possible that passage observation after administration of a contrast substance by mouth may enable one to form a more exact judgment; but in the great majority of cases that procedure will be contraindicated or impossible to carry through. It was employed only in one of our eighteen cases. The result suggested the presence of an obstruction at the junction of the jejunum and the ileum, and this was confirmed by the operation, which revealed an adhesion of a portion of the vessel wall to the anterior wall of the abdomen at that point.

To determine the causes responsible for an ileus of the small intestine, and the exact location of the obstruction, the information that can be obtained from the roentgenographs alone, without the use of contrast substance, is not sufficient. In these cases the judgement must be based chiefly on the anamnestic and clinical data. With ileus of the large intestine the case is quite different, because there is great possibility that the injection of a contrast enema may enable us to locate the site of the obstruction, and in some cases to determine the nature of the latter. Contrast enema was employed in all our 12 cases of ileus due to mechanical obstruction in the colon. In every case it stopped there, and in spite of careful attempts with changing the position of the patient and increasing the height of the fluid column we did not in any of the cases succeed in filling the colon any further.

It is now of interest to know whether the limit to the advance of the contrast substance in all cases corresponds to the place where the actual obstruction to passage through the intestine was situated. A scrutiny of the material shows that the roentgenologic and the operative findings in this respect agreed in 11 cases. Only in one case did they differ, the roentgenographs showing stoppage of the enema in the middle of the descending colon, while the operation disclosed a carcinoma corresponding to the splenic flexure. The screening had given the distinct impression

that the obstruction in the descending colon was not real, and in all the roentgenographs the gaseous dilatation was, in fact, seen to stop, anally, at a point corresponding to the left flexure. As there were enormously distended intestinal loops in the abdomen, these had probably by compressing the descending colon prevented the contrast substance from advancing farther, to the flexure. This shows that the screening plays an important rôle as supplementary aid to the evaluation of the individual case.

Conclusions as to the nature of the obstruction can be drawn only from the appearance of the outline of the limits to the contrast substance, But it is important to take note of the appearance of this outline also during the screening, because diminution or cessation of the pressure from the fluid column, combined with inability of the patient to retain the enema, may easily result in its considerable alteration, and thus make it more difficult, or even impossible, to interpret it correctly.

Of the twelve patients with ileus of the large intestine, 1 had volvolus of the sigmoid colon, 9 carcinoma, and 2 adhesions with strangulation respectively of the transverse and the sigmoid colon. The case with volvolus showed a typical picture, and presented no difficulties for the diagnosis. In 7 of the nine cases with carcinoma the obstruction was judged to be probably a tumor of malignant character; in the two others the diagnosis hesitated between tumor and strangulation, because the demarcation was linear without indentations, while the age and anamnesis of the patients pointed to tumor. In the 2 cases with adhesions the possibility of such formations had been reckoned with.

In 9 of the cases with ileus of the small intestine, contrast enema had been administered in order to strengthen the diagnosis. In 7 of them it passed freely, and the outline of the colon showed normal. In one case the examination could not be carried through, and in one the result of the injection confirmed a mistaken diagnosis still further. This was the case, already mentioned, in which the roentgenograph of the abdomen taken without the use of contrast substance had given the impression that there was gaseous distention both of the small intestine and of the cecum, while the subsequent operation showed only enormously dilated loops of the former. When the injection was given, the contrast substance stopped, without any characteristic demarcation, in the middle of the transverse colon. The observation, as we believed, of a highly distended cecum combined with stoppage in the transverse colon led us to conclude that there must be an obstruction to passage in the neighbourhood of the right flexure, as to the nature of which we could not, however, express any opinion. At the subsequent operation there were found, as already said, only enormously dilated intestinal loops and, about 65 cm. orally from the iliocecal junction, a cicatricial narrowing

of the intestinal lumen. This portion was later resected, and microscopic examination showed simple ulcerous enteritis. Except in special cases like this, contrast injection under screening is, however, a very valuable aid to diagnosis in ileus, because it enables us to make sure that an obstruction to passage is not situated in the colon, and, on the other hand, makes it possible to locate an obstruction there and, in many cases, determine its nature.

SUMMARY

On the basis of a comparison of the roentgenologic observations with the operative, resp. post mortem findings, the author discusses the value of the assistance which the roentgen diagnosis is capable of giving in cases of acute, mechanical ileus. The determination, from abdominal roentgenographs taken without the use of contrast substance, of whether a gaseous dilatation is in the small or large intestine is fairly reliable. In 16 of the author's 19 cases the operative findings agreed with the roentgen evidence in this respect. Fluid levels were present in the great majority of cases of operatively verified ileus of the small intestine and in all his 12 cases of ileus of the large intestine. To determination of the causes responsible for the occurrence of a mechanical ileus of the small intestine, and the precise location of the obstruction, the information furnished by roentgenographs taken without the use of contrast substance is not sufficient. Contrast injection under screening is a very valuable aid to diagnosis, because it enables the examiner to make sure that an obstruction is not situated in the colon, and, on the other hand, makes it possible to locate an obstruction there and, in many cases, determine its nature.

ZUSAMMENFASSUNG

Gestützt auf einen Vergleich der röntgenologischen Beobachtungen mit den operativen, bezw. post-mortem-Befunden, erörtert Verf. den Wert der Hilfe, welche die Röntgenuntersuchung in Fällen von akutem mechanischem Ileus für die Diagnose zu leisten vermag. Darüber, ob eine durch Gasansammlung bewirkte Dilatation in den Dünndärmen oder im Dickdarm liegt, erhält man durch Röntgenogramme, die ohne Anwendung eines Kontrastmittels aufgenommen werden, eine recht verlässliche Entscheidung. In 16 von den 19 Fällen des Verfassers stimmten die Operationsbefunde mit dem Ergebnis der Röntgenuntersuchung in dieser Beziehung überein. Bei der grossen Mehrzahl der Fälle von operativ verifiziertem Ileus des Dünndarms und bei allen seinen 12 Fällen von Dickdarmileus fanden sich Flüssigkeitsspiegel. Zur Bestimmung der für das Auftreten eines mechanischen Ileus des Dünndarms verantwortlichen Ursachen und zur genauen Lagebestimmung der Obstruktion geben die ohne Kontrastmittel aufgenommenen Röntgenbilder keinen genügenden Aufschluss. Kontrastinjektion unter Durchleuchtung ist eine sehr wertvolle Hilfe für die Diagnosestellung, weil sie den Beobachter instandsetzt zu konstatieren, dass im Kolon keine Obstruktion besteht, und es anderseits ermöglicht, eine an dieser Stelle liegende Obstruktion zu lokalisieren und in vielen Fällen ihre Natur zu entscheiden.

RÉSUMÉ

Se basant sur une comparaison entre l'observation radiographique et la découverte opératoire ou post-mortelle, l'auteur discute les services que l'on peut attendre de la radiologie pour les cas d'iléus aigu et mécanique. L'examen de radiogrammes effectués sans l'aide de substance de contraste et sur lesquels il a été décelé un ballonnement de gaz localisé au gros intestin ou à l'intestin grêle, présente les plus grandes garanties. Pour 16 des 19 cas de l'auteur, la découverte opératoire fut conforme à la radiographie. Celle-ci montrait les niveaux liquides caractéristiques dans la grande majorité des iléus de l'intestin grêle, vérifiés opérativement. Pour les iléus du gros intestin, la concordance fut complète pour les 12 cas présentés. En ce qui concerne la recherche causale de l'iléus mécanique de l'intestin grêle et la localisation précise de l'obstruction, les renseignements fournis par le radiogramme sans usage de substance contrastante sont insuffisants. L'injection contrastante est d'une importance considérable pour le diagnostic, car elle permet de s'assurer de ce que l'obstruction n'est pas située dans le colon. En second lieu, elle permet d'y localiser une obstruction et, le plus souvent, d'en déterminer la nature.

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DETERMINATION OF IONISATION IN BIOLOGICAL OBJECTS[1]

(Report to a Study meeting on the Measurement of Ionising Radiations, organized by the League of Nations' International Institute of Intellectual Cooperation in collaboration with the International Union of Biological Sciences)

by

R. M. Sievert

At present, the only possible method of determining the quantity of ionising radiation seems to be to employ its ability to produce ionisation in gases. Apart from geometrically defined units of γ-radiation from radium, the only suitable basis of a definition of a radiation unit is the ionisation effect, and radiation cannot be measured as unambiguously or as exactly by any other method as by the ionisation method.

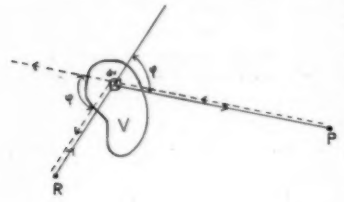
In biology and medicine, the ionisation in air has long been considered the effect which as far as quantity is concerned conforms most closely to the processes that apparently determine the biological influence of radiation. I am here presuming that this is actually the case, but at the end of my paper I will add a remark on the relation of ionisation in air to biological effect.

In the measurements of radiation at the surface and the depth of biological objects, the secondary radiation from surrounding substances plays an important part. It is remarkable that in medical radiology the essential difference in this respect between roentgen-rays below, say, 200 kV and γ-radiation has for a long time been fairly generally overlooked. Two circumstances may be said to characterise this difference.

One is that γ-radiation cannot be screened off in the same way as roentgen-rays without considerable secondary radiation arising from the diaphragms used, and the other that in γ-radiation the secondary electrons have a maximum range which is of quite different order of magnitude to those of roentgen-rays. In order to limit a beam of 200 kV roentgen-rays

[1] Submitted for publication Nov. 24, 1939.

and of the γ-radiation from a radium preparation so that in both cases the intensity of the hardest components outside the beam are reduced to, for instance, 1 % of the initial radiation, the former will require about $^1/_4$ cm. of lead, the latter about 10 cm. Secondary rays will thus be emitted from a considerably larger surface in γ-radiation than in roentgen-rays. For practical reasons that surface must furthermore be placed close to the source of the radiation. The largest part of the secondary radiation will come from the parts of the diaphragm closest to the source of the radiation, from the walls of the radium container, and from any extra filters used.



R = radiation source
P = point of measurement
V = secondary radiator

Fig. 1.

In this connection I may be allowed to draw attention to a simple, but often disregarded law mentioned in a paper of 1923 (1). If the absorption of both primary and secondary radiation are equal or can be disregarded, and if the source of the radiation is punctiform, the secondary radiation at a given point will be the same, if that point and the source of radiation change places (see fig. 1). The effect of the secondary radiation from the radium container, at the point where the radiation is measured, will thus often be the same as if that point were surrounded by the walls of the radium preparation. This law will sometimes be of importance to the secondary β-radiation, as the absorption in air, at least at short distances, can often be disregarded.

The Secondary β-Ray Emission and Ionisation Measurements in Biology

If the air ionisation in a small volume is to be measured, it will in the first place be necessary to consider the secondary electrons coming from all directions and emitted in a volume, the boundary surface of which is determined by the range of the secondary electrons. This volume from which the electrons contributing to the ionisation originate, may be called »the active volume of secondary electron emission» or, briefly, the *active volume.*

Assuming a homogeneous medium and a homogeneous field of radiation the active volume will form a rotation body, the axis of which is parallel to the primary rays. The shape of this body differs according to the material, and according to the direction and wavelength of the radiation field. It will largely depend on how the secondary electrons in

the active volume are produced, i. e. on the ratio between the ionisation power of the photo and Compton electrons.

A radiation field is determined by three factors: direction, intensity, and quality. In case of constant intensity and quality, two extremes may be distinguished, viz. cases where the direction of the radiation is the same everywhere in the field (A), and cases where all directions of radiation are equally represented at every point of the field (B). Owing to secondary radiation, the first extreme can only occur in a vacuum. The latter extreme, on the other hand, will occur in a limited region when a volume is exposed to radiation from all sides, provided that the absorption of primary radiation may be disregarded and the secondary radiation has reached a saturation value.

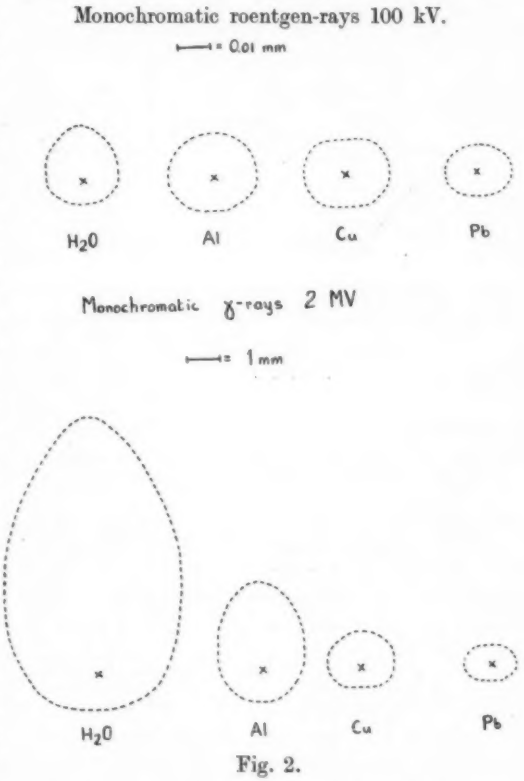


Fig. 2.

Assuming that the introduction of the active volume alone will not appreciably change the radiation field, the extent of the active volume can in either case be estimated using information regarding the range of the secondary electrons. In Table I I have collected some data regarding the range of electrons of various energies and for different deflections when using monochromatic primary radiation of wavelengths corresponding to 100 kV and 2 MV. Fig. 2 gives a rough picture of the form and dimensions of the active volume in some different substances in these two cases. The dimensions given refer to electrons of the highest velocities, and may probably, for the purposes of computing the contributions to the ionisation in practice be reduced by half.

Radiation fields of the kind considered in these calculations are of course rarely met with in radiology, but it may be assumed that if the

Table I

Range of Electrons in Water.

Energy kV	mm H_2O	Energy kV	mm H_2O	Energy kV	mm H_2O
30	0.02	150	0.24	600	2.25
40	0.03	175	0.30	800	3.3
50	0.045	200	0.38	1 000	4.2
60	0.06	250	0.56	1 250	5.5
80	0.095	300	0.79	1 500	6.8
100	0.135	400	1.3	1 750	8.3
125	0.19	500	1.8	2 000	9.8

Radiation	Quantum defl. angle	Electron emiss. angle	Electron energy kV	Range of electrons in mm H_2O
Roentgen-rays	10°	84°	0.3	
	20°	78°	1.22	
Quantum energy	30°	66° 20′	4.5	0.0004
100 kV	60°	55° 20′	9.1	0.002
	90°	40° 10′	16.7	0.006
	120°	25° 40′	23.1	0.011
	180°	0	28.6	0.017
	Photoelectrons		≤100	≤0.13
γ-rays	10°	66° 30′	120	0 15
	20°	48° 35′	385	1.0
Quantum energy	40°	28° 45′	970	4.6
2 MV	60°	20° 10′	1 330	5.4
	90°	11° 20′	1 600	7.0
	120°	6° 35′	1 710	7.5
	180°	0	1 780	7.9
	Photoelectrons		≤2 000	≤9.8

depth in the tissue is sufficiently large the active volume will become practically the same as in case B, at least if the primary radiation is of relatively long effective wavelength. With hard radiation its shape — especially near the surface of the object — will be more like that of case A.

If the radiation incident on the surface is divergent and consists of very short waves, the significance of that part of the active volume which is nearer to the source of the radiation will obviously increase, and the radiation intensity at the point in question will consequently depend even more on the substances situated between it and the source of the radiation. This is worth noting, both in teleradium therapy and when the radium preparations are applied directly on the skin or inside the tissues.

If the active volume falls wholly within the biological object, the conditions are generally relatively favourable for measuring the radiation.

If, however, that volume also contains heavier substances, of which the most general are perhaps metals of high atomic numbers — as will frequently happen in implantation — the deviations from this normal case will be considerable. Conditions will be even more complicated in the determination of that ionisation on the surface of a biological object, which is of interest from a medical point of view. One reason for this is that most biological surfaces are covered by a more or less thick layer of dead material, a *dead layer*, which in all probability does not contribute to the production of the biological reaction.

It is consequently *a priori* uncertain where in the superficial layer the radiation ought in a given instance to be measured. There is moreover also often the even more delicate question: at what depth below the surface represented by the first living cells do the effects of the radiation begin, which are responsible for the biological change to which our interest in the quantitative determination of the radiation on the surface is due? I shall not attempt to deal now with these probably very complicated problems but will assume that the skin reaction primarily depends on the effect in the basal cells, and that the dead layer is practically identical with the epidermis.

The thickness of the epidermis varies of course greatly in different parts of the body, and individual variations are also quite appreciable. The limit values are supposed to be 0.02 and 4 mm. On the face the thickness has been found to vary from 0.025 to 0.040 mm. In most cases the thickness may be assumed to vary from 0.03 to 0.1 mm.

If the dead layer is sufficiently thick, or covered by a substance of approximately the same atomic composition and specific gravity as the tissue so that the whole active volume will fall within the tissue and that substance, conditions will obviously be the same as when determining the radiation in the depth.

If we examine the conditions defining the biologically active superficial ionisation in radiations of different wavelengths, it should first be noted that in ultra-soft roentgen-rays, e. g. of the kind used in Grenz ray therapy the difficulties are greatly increased by the absorption in the dead layer. The half value layer of Grenz rays generated at, say, 7 kV is something like $^1/_2$ mm. in water, and an error of only a few tenths of a mm. in estimating the thickness of the dead layer will make the determination in roentgens of the erythema dose very uncertain.

In roentgen-rays generated at 20—200 kV, conditions are favourable for determining the ionisation on the surface. The absorption in the dead layer will in this case usually be small enough to be disregarded, and the active volume will be so small that it cannot conceivably, except at the highest voltages and thinnest of dead layers, extend into the medium covering the skin surface.

Complications will again arise in connection with hard roentgen-rays, e. g. those used in high voltage roentgen-ray therapy, and especially with γ-radiation. They are most pronounced in the hard γ-radiation, where the active volume in air is several metres in extent. The masses emitting β-rays, often consisting of the metal surfaces of the diaphragm and filter of the apparatus in or near a line through the radiating source and the point where the measurements are taken, are then of great importance. If the masses liable to emit secondary β-rays towards the point of measurement are varied without altering the absorption in the primary beam, it will be found that the ionisation, measured with a thin-walled chamber, may vary within $\pm$ 20 % or more. The simple geometrical law to which I have just referred may in such cases occasionally prove suitable for a comparative estimate of the secondary radiation.

As to the erythema dose the rule is consequently that if the active volume contains quite different atoms than the tissue, or if the absorption of the primary radiation in the dead layer cannot be disregarded, the ionisation of the radiation which causes the erythema cannot be determined unless the wall thickness of the ionisation chamber is equal to the thickness of the dead layer, or the ionisation is determined by interpolation between observations made with chambers of different wall thicknesses.

The fact that the secondary β-radiation, the importance of which in radium therapy I pointed out in a paper in 1923 (1), really has a distinct effect in practice, has been demonstrated by BENNER and SNELLMAN (2), who have examined the erythema resulting from the use of radium preparations surrounded by platinum or by palladium. The emergent β-radiation is considerably weaker from the latter metal than from the former one. There was a distinct difference in the erythema, although the filtration was the same in both cases.

From what has now been said about secondary β-radiation, it is quite evident that if the absorption of the primary radiation in the walls of the ionisation chamber is disregarded, the ionisation in a small chamber will increase with the wall thickness until the β-radiation has reached its saturation point, a fact which has long been known.

Ionisation in a Small Air Cavity and Ionisation Measurements at very Small Electrode Distances

Taking the secondary emission of electrons to be the factor mainly determining the ionisation of a small air volume enclosed in an absorbing medium, BRAGG (3), 1912, FRICKE and GLASSER (4), 1925, and GRAY (5), 1928, have — independently of one another — demonstrated the possibility of ascertaining in a simple manner the relation between the radia-

ion energy absorbed in a medium and the ionisation produced in a small air-filled cavity in that medium.

FRICKE and GLASSER (4) dealt with the various conditions governing the measurement of roentgen-radiation, beginning with small ionisation chambers with »air walls», which they considered ought to have the same effective atomic number as air to make the observed ionisation independent of the wavelength in the same way as in a free air chamber. GLASSER, PORTMAN and SEITZ (6), GLASSER and VICTOREEN (7), MEYER (8), and others, have since proved that this is not quite correct, even in respect of substances of low atomic numbers, as independence of wavelength is only achieved if the effective atomic number is lower than that calculated by FRICKE and GLASSER (4). Table II — from a paper by MEYER (8) — gives an example of this.

Table II

Air Wall Chambers (of carbon + an added substance) according to Meyer (8).

Added substance	%	Effective atomic number		Rel. amount of electrons per unit volume of chamber mat.
		added substance	chamber	
SiC	3.57	12.6	6.55	1.130
Al_2O_3	4.0	11.17	6.47	1.134
$MgCO_3$	5.63	9.36	6.31	1.134
BeO	9.0	7.14	6.13	1.140
C	—	6.00		
Air	—	7.96		

As the recoil electrons will contribute more to the ionisation in hard than in soft radiation, there was reason to think that in γ-radiation the ratio of ionisation for chambers of different materials excluding elements of high atomic numbers should be practically independent of the quality of the radiation. This has also proved to be the case. RANN (9) has for instance found that with chambers of elektron metal and celluloid the ratio of the observed ionisation is constant at qualities used in γ-ray therapy. He found the values given in table III in water phantoms.

I am not going into the details of the investigations regarding the influence of the chamber wall made by various authors, but will only say that in roentgen-radiation we are restricted to »air» materials, while in γ-radiation light metal or aluminium chambers can also be used. In respect of high voltage roentgen-rays there is not yet sufficient experience from which to draw any definite conclusions regarding the significance of the wall material. For effective wavelengths of up to about 50 XU,

Table III

A Comparison of Elektron Metal and Celluloid Chambers in Water according to RANN (*9*).

Distance along axis of beam in cm	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.5	2.0	2.5	3.0	3.5	5.5
Ratio of ionisation elektron/celluloid	1.19	1.20	1.18	1.20	1.20	1.21	1.19	1.20	1.19	1.20	1.20	1.19	1.22

however, it would seem that light metal chambers ought to give satisfactory results.

The method of determining the quality of the radiation in the tissues, used by MAYNEORD (10) for roentgen-rays and recently by WILSON (11) for γ-radiation, should also be mentioned in connection with the subject of wall materials. That method is based on the dependence on wavelength of chambers made from materials of medium atomic numbers. By observing the ratio between such a chamber and an air-wall chamber, it is possible to compute the effective wavelength of the radiation. As regards the influence of the shape of the ionisation chamber interesting observations have been made by FAILLA and MARINELLI (12), and others.

GRAY's theoretical treatment of ionisation in a small air-filled cavity of an absorbing medium has given us a clearer idea of the factors determining the air ionisation in small ionisation chambers, as well as a method of absolutely determining the absorbed energy. If GRAY's theory corresponds to actual conditions, it will provide a correct theoretical basis from which we have a good chance to define a unit suitable for all ionising radiation.

The experimental attempts so far made to verify GRAY's theory are, however, relatively few, and the results differ to some extent. There are two possible ways in which the theoretical premises can be checked. One is to observe the ionisation in chambers of different sizes and of different materials, the other to investigate the ionisation in a given chamber at various air pressures.

As it is of decisive importance to know if GRAY's theory agrees with the actual facts, I have thought if suitable to collate here some of the results obtained in experiments with chambers of different sizes and shapes, some of them with different electrode materials and at varying pressures. The theory presumes that the path of the secondary electrons in crossing the cavity is a negligible fraction of their whole range. GRAY considers that for the validity of his theory »the approximate limit to the linear dimensions for γ-ray measurements is of the order of a few millimetres, and for hard roentgen-radiation (200 kV const. pot. 1.5 mm. Cu

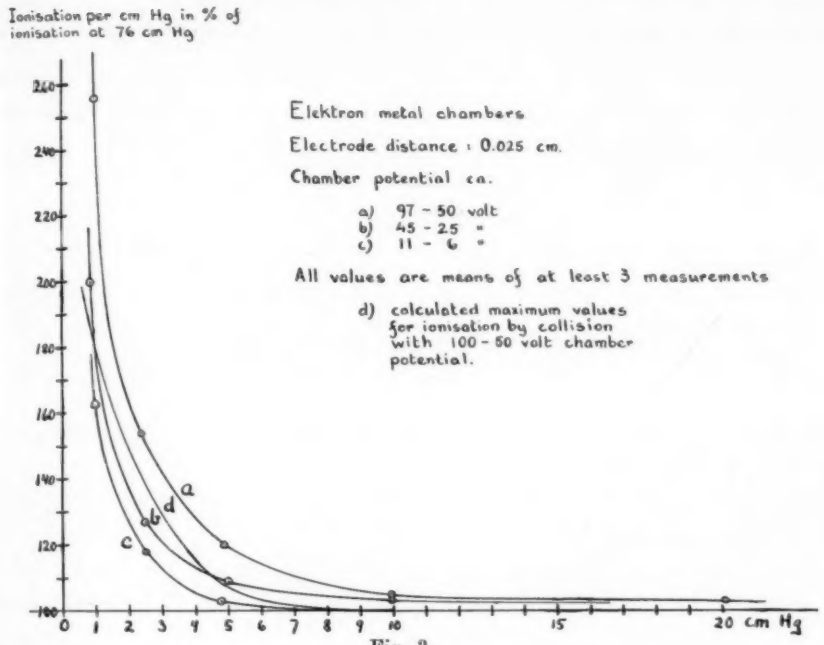

Ionisation per cm Hg in % of ionisation at 76 cm Hg
Elektron metal chambers
Electrode distance : 0.025 cm.
Chamber potential ca.
a) 97 - 50 volt
b) 45 - 2.5 "
c) 11 - 6 "
All values are means of at least 3 measurements
d) calculated maximum values for ionisation by collision with 100 - 50 volt chamber potential.
240
220
200
180
160
140
120
100
0 1 2 3 4 5 6 7 8 9 10 15 20 cm Hg
a
b
c
d

Fig. 3.

filter) of the order of 0.1 mm. For softer roentgen-radiation it is smaller still.» (13)

Table IV contains some data from experiments so far made relating to the dependence of ionisation on volume and pressure. Although in most investigations the authors have either come to the conclusion that the ionisation is proportional to the volume, or found that in view of the magnitude of the experimental errors the observed deviations cannot be considered significative, the data nevertheless give the impression that, irrespective of the possibility of ionisation by collision, the ionisation per unit volume may actually increase when the electrode distances decrease.

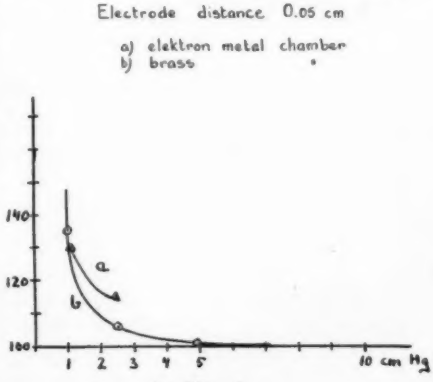


Fig. 4.

Together with BENNER and

Table

Author	Radiation	Ionisation chamber	Material of chamber
H. Fricke & O. Glasser Amer. J. Roentgenol. 13, p. 453—461, 1925 (13, p. 462—464, 1925)	Roentgen-rays 100 kV, 1 mm Al — 200 kV, 0.52 mm Ag + 0.75 mm Cu + 1 mm Al	Cylindrical. 0.6—2 cm Rectangular. 3.0 × 3.0 × 0.5 cm	C and Al
H. Th. Meyer Strahlenther. 41, p. 185—196, 1931	Roentgen-rays HVL 0.51—4.86 mm Al	Plane electrodes. Rays limited by lead diaphragm. Diam. 0.4—1.0 cm	Carbon with Al_2O_3
H. Th. Meyer Strahlenther. 41, p. 309—320, 1931	Roentgen-rays HVL 0.04—1.78 mm Cu	Spherical. Outer electrode 1.5—1.9 cm	Carbon with Al_2O_3
E. Albrecht Strahlenther. 42, p. 328—336, 1931	γ-rays	Cylindrical. Diam. 2.5—5 cm	Carbon bakelite
E. A. Owen & H. I. Jones Brit. J. Radiol. 4, p. 309—338, 1931	Roentgen-rays 37—100 kV	Cubical. Ca 1—4 cm	Graphite 1.5 cm thickness
R. M. Sievert Acta Radiol. Suppl. 14, p. 82, 1932	γ-rays 50 mg Ra Distance 2 and 4 cm	Spherical cond. chamber. Inside diam. 0.65—1.0 cm	Elektron metal. 0.2 cm thickness Inner electrode 0.6 cm
E. Miehlnickel & B. Rajewsky Strahlenther. 50, p. 499—515, 1934	Roentgen-rays 165 kV, 0.5 mm Cu + 1 mm Al	Spherical. Outer electr. diam. 1.8 cm	Graphite + celluloid + silicon
E. Miehlnickel Ann. der Physik 20, p. 737—772, 1934 Strahlenther. 54, p. 348—358, 1935	Roentgen-rays 25 kV, no filter 145 kV 0.8 mm Cu	Plane electrodes. Diam. 1.5 cm	(97 % C, 3 % Si) + 35 % celluloid C and Al
Fr. Keller Strahlenther. 52, p. 403—424, 1935	γ-rays 50 mg Ra, 0.5 mm Pt	Spherical. Inside diam. 0.6, 0.9, 1.2 cm	Brass, 0.05 cm thickness
W. Friedrich & R. Schultze Strahlenther. 54, p. 553—569, 1935	γ-rays	Spherical. Inside diam. ca 1.3—11 cm Cylindrical of diff. diam. and length but const. volume and cyl. of const. diam. and diff. length	S-Graphite (Siemens-Plania) 0.4 cm thickness »
L. H. Gray Proc. Roy. Soc. 156, p. 578—596, 1936	γ-rays »A few millicuries radon filtered with just suff. mat. to stop the fastest natural β-particles»	— — —	Graphite 0.4 cm thickness » Lead

IV.

Electrode distance cm	Air pressure cm Hg	Air volume cm^3	Tot. irr. electrode area divided by air volume	Result
0.22—0.95	76	0.48—4.91	10—3.4	Ionisation prop. to volume.
0.24	76	4.47	8.0	
0.86—1.86	76	0.11—1.52	2.3—1	Small deviations (5—8 %) from proportionality with volume, probably due to secondary electrons from the electrodes and metal parts.
0.36—0.38	76	1.69—2.79	5.7—5.5	With different ratio total irradiated electrode area/air volume, the chamber wall must be made of carbon with different content of Al_2O_3, if the chambers shall be independent of quality.
ca 1.8—2.3	76	31—90	ca 1.9—1.2	Ionisation prop. to volume if wall thickness sufficient ($\geq$ 4 mm graphite).
0.5—2	76	0.9—63.6	6—1	Ionisation prop. to volume.
0.025—0.20	76	0.031—0.411	80—10	Ionisation 5 % higher with smallest chamber.
0.85—0.26	76	3.21—1.93	7.9—3.2	Ionisation prop. to volume except for the smallest electrode distances (ca 0.3 cm) where the ionisation per cm^3 was ca 7 % too large.
0.1—3	76	0.05—1.5	20—0.67	With celluloid-carbon-silicon electrodes ionisation proportional to volume for soft rays. Deviations from proportionality increasing with hardness up to 200 % for the smallest electrode distance. HENSCHKE and GRAY have pointed out some errors in these experiments.
0.2—0.5	76	ca 0.1—0.9	ca 20—4	Ionisation prop. to volume.
	76	1—675	ca 4—0.5	Ionisation prop. to volume and independent of type of chamber.
	»	—	—	
—	20—74	0.1	—	Ionisation prop. to pressure.
—	10—74	2.0	—	»
—	20—74	0.1	—	Ionisation per cm Hg increasing with decreasing pressure. Max. diff. 7 %.

Table

Author	Radiation	Ionisation chamber	Material of chamber
E. Miehlnickel & H. Osterwisch ZS f. Physik 101, p. 352—371, 1936	γ-rays 0.72 mg Ra Distance 20 cm	Spherical. Inside diam. 0.4—2.0 cm Electr. diam. 0.1—0.5 cm	(97 % C, 3 % Si) + 35 % Celluloid. 0.04 mm thickness. Inner electrode of C
M. Dorneich Fortschr. a. d. Geb. d. Röntgenstr. 57, p. 189—199, 1938	Roentgen-rays 165 kV max. 0.5 mm Cu + 1 mm Al Distance 50 cm	Spherical. Inside diam. 0.39—1.94 cm	97 % C, 3 % Si Inner electr. of C., diam. 0.11—0.51 cm
H. Henschke Strahlenther. 62, p. 614—638, 1938	Roentgen-rays 50—145 kV 0.05—0.82 mm Cu	Spherical. Inside diam. 0.4—1.2 cm	(97 % C, 3 % Si) + 35 % Celluloid. 1 mm thickness
	50—165 kV 0.05—1.00 mm Cu Distance 27 cm	Spherical. Inside diam. 2.0 cm Electrode 0.3 cm diam.	»
	50—145 kV 0.05—0.82 mm Cu	Cylindrical. Length ca 3.8 Inside diam. 2.1 cm Inner electr. of diff. diam.	Graphite covered with air mat. 0.2 cm thickness
	» Distance 2.5 m	Plane electrodes	Disc of air mat. 1.5 cm diam. 0.8 cm diam. of radiat. cone

[1] All these experiments showed a slight increase of the ionisation with decreasing volume

Bernstedt I have lately investigated how the ionisation depends on the pressure in condenser chambers (14) with extremely small electrode distances, in an attempt to ascertain whether ionisation by collision can have occurred or not. The results are shown in figs 3 and 4.

The most plausible interpretation of the curves obtained would seem to be that ionisation by collision will at lower pressures increase the ionisation. That conclusion is also supported by the fact that lower curves are obtained at lower charging voltages. Curves calculated for the maximum effect of ionisation by collision, however, give considerably smaller values than those observed.

In order definitely to ascertain at least that the ionisation by collision is not the only cause of the observed effect, the experiments were repeated at as low a voltage as 11 volt (see fig. 3), which is considerably less than the ionisation potential of nitrogen (15.8), oxygen (13), carbon dioxide (14.3), water (13.2), and argon (15.7). To test the effect of different electrode materials we also made comparative experiments with electron metal and brass chambers. The results are given in fig. 4. In our opinion

IV (continued)

Electrode distance cm	Air pressure cm Hg	Air volume cm^3	Tot. irr. electrode area divided by air volume	Result
0.15—0.75	76	0.03—3.7	ca 17—3.5	Ionisation per cm^3 decreasing down to 1.5 cm^3 volume, then increasing from 4 to about 6 at 0.03 cm^3.
0.14—0.71	76	0.031—3.75	17—3.4	Ionisation per cm^3 increases with decreasing volume for smallest chambers (1—0.031 cm^3 volume) from 100 to about 270.
0.15—0.55	76	0.03—0.9	20—5	Ionisation prop. to volume. [1]
0.85	0.3—75	4.2	3.0	Ionisation per cm Hg increasing with decreasing pressure below ca 10 cm Hg. With 0.3 cm Hg 17—28 % higher ionisation than at 75 cm Hg.
0.07—0.56	76	2.45—11.8	25—3.7	Ionisation prop. to volume. [1]
0.1—1.0	76	0.177—1.77	5.7—0.57	Ionisation prop. to volume. [1]

though within the experimental errors.

it is not possible to state the effects observed to be due to ionisation by collision only. The experiments will be continued.

It would thus seem that the condition essential to GRAY's theory — constant ionisation per unit volume in a small air-filled chamber — is not fulfilled, and that a surface effect, the nature of which is still unknown, is making the basis of our present conception of ionisation in absorbing media uncertain. If our experiments can be explained by an increase in the density of the ions near the surface, the variations of this effect with the nature of the wall material and the gas are of certain importance. It is not absolutely impossible that such investigations might lead to a partly new conception of the ionisation that takes place in an infinitesimal cavity in the tissue.

The International r-Unit

A unit for measuring radiation in biological and medical work must fulfil the following fundamental conditions:

1:o. The unit must, at least theoretically, permit an unambiguous and exact determination of the radiation in every case when such determination is required.

2:o. Measurements in this unit must be sufficiently accurate for all practical purposes, and the measuring methods and instruments must be as simple as possible.

Before it was changed in Chicago in 1937, the international r-unit did not fulfil these conditions, except in respect of roentgen-radiation generated by moderate voltages. Even then, the measuring arrangements required by the definition of the unit were unnecessarily voluminous and complicated. Neither ultra-hard roentgen-radiation nor γ-radiation could, as a matter of fact, be measured conformably to the definition, nor could the unit be applied to the secondary radiation from any irradiated medium, whatever the quality of the radiation. Even with the alterations made in Chicago, it is doubtful whether the r-unit fulfils the above conditions.

The following objections have been raised to the use of the r-unit for γ-rays:

1:o. There is no marked need of a common unit for roentgen-rays and γ-radiation.

2:o. The technique is so different in roentgen-radiation and in γ-radiation that a direct comparison of the results of each seems more or less absurd or unnecessary.

3:o. In γ-radiation treatment the intensity is generally so much smaller than in roentgen-radiation that the consequent biological results will differ, and a direct comparison of the results obtained by roentgen-rays and by radium is for that reason, too, very rarely possible.

4:o. The uncertainty in the determination of the dose is so much greater in radium therapy than in roentgen-ray therapy that the introduction of the r-unit, which is regarded as fairly exact, would in radium therapy give an illusion of exactitude which by no means corresponds to the reality.

5:o. γ-radiation cannot be measured in accordance with the definition of the r-unit.

The last of these objections to the adoption of the r-unit for γ-rays is not actual now, all the more as KAYE and BINKS (15) have shown that γ-radiation can be measured by a free air chamber, although the technical arrangements are complicated. The technical progress in the production of high voltage roentgen-rays has also in recent years changed the conditions in another respect. Even though it is not yet possible to say whether the use of ultra-hard roentgen-rays is a considerable advance

in radio-therapy or not, we must remember that the difference in wavelength between radium and roentgen-radiation does not exist in the same sense today as formerly. Teleradium is being increasingly used, in the not too distant future with perhaps even larger quantities than hitherto, and the technique of radium treatment may therefore approach that of roentgen-ray treatment. A common unit may perhaps now be well-grounded. On the whole the r-unit, as defined in Chicago in 1937, seems suitable for this purpose. In my opinion it might be desirable to alter the definition of the r-unit so as to emphasize still more its character of an ionisation unit. The unit should moreover be not a dose-unit, but an intensity unit or a dosage-rate unit. If the r-unit were not already so well known, I would like to propose, say, the number of ions per cub.cm. and second $\times 10^{-10}$ as a unit of intensity. The r-unit has now been in use for so long, however, that considerable inconvenience would probably be caused by the introduction of a new unit. Owing to our lack of knowledge of the mechanism of the biological effects, it is also advisable to regard the r-unit a provisional unit, for as we learn more of the mechanism of the biological effects of radiation, new and quite different demands on radiation units for biological and medical purposes will certainly arise. I believe that in the next few years radiological research will bring to light so many biological difficulties in estimating the effective dosage that the question of units will become a question of less importance. Obviously, there is at present no reasonable proportion between for instance the extreme accuracy with which we attempt to determine the dose given and our knowledge of the importance of conditions like, for instance, the time factor and the varying radio-sensitivity of tumours. Nor must it be forgotten that we have now, largely by means of the method of protraction and of divided doses (COUTARD), reached a new phase in the development of radiotherapy, in which the risk of damage to the skin is no longer of the same importance as formerly.

In concluding my report, I wish to emphasize that our lack of knowledge, not only of the ionisation near the surface of different substances, but also — and not least — of the mechanism of the biological effects of radiation, gives us reason to question the suitability and reliability of the present ionisation methods as a means of measuring radiation for biological and medical purposes. In practice, the ionisation method of measuring the doses of roentgen- and γ-radiation actually presumes *either* that the biological effect in a given irradiation time is unambiguously determined by the ionisation intensity, irrespective of wavelength and corpuscle velocity, *or* that the intensity distribution in the spectra of both wave and corpuscle radiation is known at that point in the object, where the expected biological effect is to be stated.

SUMMARY

The author calls attention to the imperfections of the present way of determining the radiation on the surface and in tissues of biological objects, especially in comparing hard γ-radiation with soft roentgen radiation. The present measuring method is based on the supposition, that the ionisation in an infinitely small air volume in the tissue under any circumstances is approximately equal to the ionisation in a thimble chamber made of air material.

The author collates investigations made by various authors in the last years on the relation of the ionisation to the size of the ionisation chamber. He also reports some of his own experiments, which seem to indicate that still unknown effects will appear in small chambers which makes the reliability of the ionisation methods for determining dosage in the form now used rather doubtful.

ZUSAMMENFASSUNG

Der Verfasser hebt einige Mängel hervor, die der jetzigen Art, die Bestrahlung der Oberfläche und des Gewebes von biologischen Objekten zu bestimmen, anhaften, besonders wenn es sich um Vergleiche zwischen harter γ-Strahlung und weicher Röntgenstrahlung handelt. Die heutige Methodik gründet sich auf der Annahme, dass die Ionisation im Gewebe in einem unendlich kleinen Luftvolumen unter allen Umständen annähernd gleich der Ionisation in einer Fingerhutkammer aus Luftmaterial ist.

Der Verfasser stellt Untersuchungen verschiedener Verfasser über die Abhängigkeit der Ionisation von der Grösse der Ionisationskammer zusammen. Er beschreibt auch einige eigene Versuche, die darauf hinzudeuten scheinen, dass bei der Ionisation in kleinen Kammern noch unbekannte Effekte auftreten, was Anlass zu Zweifeln an der Zuverlässigkeit der zur Zeit für die Dosierung gebräuchlichen Ionisationsmethode gibt.

RÉSUMÉ

L'auteur tire l'attention sur les imperfections dans la manière présente de déterminer la radiation sur la surface et dans le tissu d'un objet biologique, surtout en comparant la radiation γ dure et la radiation Roentgen molle. La méthodologie présente est fondée sur la supposition, que l'ionisation dans un volume d'air infiniment petit est dans tous les cas à peu près égal à l'ionisation dans une chambre à dé faite de matériaux d'air.

L'auteur rapproche des investigations par divers auteurs pendant les dernières années sur la rélation entre l'ionisation et la grandeur de la chambre d'ionisation. Il rapporte aussi quelques propres expériences, qui semblent indiquer, que des effets jusqu'ici inconnus paraissent dans l'ionisation en petites chambres, ce qui donne sujet à doute de l'exactitude de la méthode d'ionisation pour dosage dans la forme actuellement employée.

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FROM THE DEPARTMENT OF RADIO-PATHOLOGY, RADIUMHEMMET, STOCKHOLM.
(CHIEF: O. REUTERWALL, M. D.)

STUDIES ON THE LIBERATION OF SULPHURIC ACIDS FROM THE GRANULES OF THE MAST CELLS IN THE SUBCUTANEOUS CONNECTIVE TISSUE AFTER EXPOSURE TO ROENTGEN AND GAMMA RAYS[1]

Preliminary report by

Bengt Sylvén

Introduction

The mast cells are found in varying numbers in the connective tissue of most vertebrates, and they constitute a characteristic cell type with slow amebism. In their cytoplasm there are granules containing heparin (HOLMGREN & WILANDER 1937). — Heparin is a mixture of mucoitin polysulphuric acids (JORPES & BERGSTRÖM 1936), and they contain various amounts of sulphuric acids in ester linkage (studied by JORPES). The inhibitory effect of heparin on blood coagulation has been studied by several authors.

The granules of the mast cells are, in most species, soluble in water. To avoid dissolving heparin from the mast cells in the histological preparation of a tissue, one must use specific fixation fluids that precipitate heparin. The very best results are obtained, according to HOLMGREN (1938), by using a 4 % solution of basic lead acetate in dist. water as a fixative. With this method all heparin will be precipitated.

In consequence of the content of sulphuric acids in ester linkage, the granules of the mast cells stain methachromatically with basic »methachromatical» aniline dyes (e. g. with Toluidinblue (GRÜBLER)). This staining reaction is a characteristic and specific quality for all organic sulphuric acids with a high molecular weight (LISON 1935).

[1] Submitted for publication Febr. 22, 1940.

As to the function of the mast cells very little is known. According to researches by WILANDER (1938), the mast cells deliver heparin to the blood.

In connection with the use of Toluidinblue in studying the presence of sulphuric acids of high molecular weight in various tumor tissues, some interesting facts were elicited. In all cases of carcinomas the author found a great amount of mast cells surrounding the growing tumor tissue. In carcinomas that had been previously treated with roentgen or radium, and where no growing tumor tissue was found, no mast cells or only a few remained in the stroma.

Those observations suggested the question, what had happened to the mast cells in the course of radiation therapy. This question has been of little interest previously, because of our scanty knowledge of the presence, the function and the chemistry of the mast cells.

Historical Review

In the literature the author found a few previous investigations dealing with this question.

BIERICH (1922) treated the skin on the dorsum of rats with filtered roentgen rays in various dosages. The treated skin areas were examined at different times after treatment (from 5 min. to 5 days). No report of the fixative was made. For the staining BIERICH only used staining methods for elastic tissue. — BIERICH states that, after short roentgen treatment, he found *an increase in the number of mast cells and elastic fibers in the connective tissue of the skin.* Those changes were observed as soon as 5 min. after treatment, the same changes being seen up to 5 days after treatment. After heavy doses there should be a temporary decrease in the number of mast cells and elastic fibers, but 4 days after treatment another increase was observed. — BIERICH believed that the increase in the number of mast cells was to be explained by the migration of mast cells from the surrounding untreated tissue.

Those researches were repeated by DUSCHNITZ (1924), who used methachromatic dyes (UNNA's »Polychrome») to make the mast cells clearly visible. DUSCHNITZ found *neither an increase of the number of mast cells nor an increase of the number of elastic fibers in the skin after roentgen treatment.* He stated that no positive changes of the mast cells occurred.

In works on the changes in normal and tumor tissue after radium treatment no observations concerning the mast cells have been made.

The statements mentioned above afford no answer to the question suggested by the observations made by the author, who has therefore made some investigations on this subject.

The Author's Researches

The experiments were performed on rats. This animal was chosen because the granules of the mast cells in rats are not so readily soluble in water as those of other animals (e. g. rabbits and guinea-pigs) (HOLMGREN 1938).

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The Author's Researches

The experiments were performed on rats. This animal was chosen because the granules of the mast cells in rats are not so readily soluble in water as those of other animals (e. g. rabbits and guinea-pigs) (HOLMGREN 1938).

Control animals were not treated with radiation. They were used as controls for the study of the number of mast cells, their distribution and the amount of granules in the mast cells of the normal abdominal wall. Pieces of the abdominal wall, including the skin, were therefore cut out and prepared for microscopical examination.

The animals of the experimental series were all treated with roentgen or γ-rays in various doses. All radiation was given on the same area of the skin on the abdomen. At different times after the conclusion of the radiation, pieces of the whole abdominal wall were cut out and prepared in the same way as the pieces mentioned above from the control animals.

Technique of the roentgen treatment. The animals were covered with lead plates except for a field of the abdominal wall, measuring 5 by 5 cm. This field was treated with roentgen from a constant potential therapy apparatus (GREINACHER type). Two different series of animals were, in one treatment, given doses of 1,000 *r* and 1,500 *r* resp. (Phantom measurement.). Dates of the roentgen treatment: 140—170 kv., 4—6 mA., 25 cm. S. T. D.; Filter: 0.5 mm. Cu + 1 mm. Al.

Technique of the radium treatment. For the γ-ray treatment surface applications of radium tubes in glass capsules were employed according to methods and calculations described by STRANDQVIST (1939). Glass applicators containing 10 capsules in two rows, each capsule containing a needle of 10 mg. radium element, were thus placed in direct contact with the skin on the abdomen of rats for 2, 3 or 4 hours. — According to intensity curves calculated by STRANDQVIST, the maximal intensity of γ-rays at a depth of 3 mm. from the skin surface was 525 *r* per hour. The surface dose was 920 *r* per hour in the centre of the field.

In the author's experiments the following doses of γ-rays were thus given to different groups of animals at a depth of 3 mm. from the surface of the skin: animals treated for 2 hours 1,050 *r*, animals treated for 3 hours 1,575 *r*, and animals treated for 4 hours 2,100 *r*.

Technique of the microscopical preparation. Immediately after the animals had been killed and pieces had been cut out from the depilated abdominal wall, the pieces were fixed in a solution of basic lead acetate (4 %) for 24 hours. After removal of the water, they were embedded in paraffin and sectioned as usual. Slices were stained with the following dyes: (1) ½ % Toluidinblue in dist. water, (2) ½ % Toluidinblue in 10 to 70 % alcohol solution, (3) the WEIGERT hematoxylin — VAN GIESON method and (4) the WEIGERT method for elastic tissue.

The Author's Results

The experiments are still proceeding. At present only the early microscopic changes of the granules of the mast cells and the early change

n the distribution of sulphuric acids in the skin after radiation have been tudied, and I wish to give a preliminary report of these results. Starting vith observations on the normal skin of rats, the changes after radiation vill then be described.

Skin of the control animals. When studying the slides, stained in Toluidinblue, from control animals it will be found that all tissues of the bdominal wall from epidermis to peritoneum are stained in a general lue or bluish green tint. According to LISON (1935), this means that those issues do not held any organic sulphuric acids of high molecular weight.

The connective tissue of the hair papillae and of the hair follicles is tained methachromatically (red; described by HOLMGREN 1938). In the orium and loose subcutaneous connective tissue varying numbers of mast cells are found with granules that are stained in the methachromatic tint (dark red to violet). According to LISON (1935), the elements mentioned above contain organic sulphuric acids of high molecular weight.

Mast cells in the subcutaneous tissue are large and ovoid, and their cytoplasm is full of granules. There are only a few mast cells in the corium; their cytoplasm is angular or irregular in shape and usually contains but few granules.

When basic lead acetate is used as fixative, according to HOLMGREN's method, all granules of the mast cells will be completely fixed and will not be dissolved during the preparation of slides. On microscopic examination they appear as distinct round granules. — Occasionally one finds a few granules lying in the connective tissue outside the cytoplasm of the mast cells. This has been described earlier by several authors and is probably an artefact.

From this description it is clear that substances which exhibit real methachromatical staining reaction, are limited to certain well defined tissue elements in the skin. Neither the cells of the normal epidermis no the cell territories of the normal connective tissue of corium, subcutis or the subperitoneal tissue, nor the normal muscular tissue, contained any methachromatical substances.

Changes after radiation. Early microscopical changes in the skin after exposure to roentgen or γ-rays are known to be of edematous and inflammatory character, the degree of inflammation depending upon dosage and length of exposure.

On the changes after roentgen treatment. After roentgen treatment of low dosage (1,000 *r* and 1,500 *r*), the following characteristic changes appeared in the treated skin areas:

(1) In all connective tissue of corium and subcutis there appeared, one or two days after roentgen treatment, substances exhibiting methachromatical staining reaction. Those substances were diffusely distributed in the cell territories of the fibroblasts. The collagenous bundles seemed

swollen, and they showed methachromatical stainability in treated skin areas. The approximate degree of methachromatical staining reaction and its presence after radiation is shown in Fig. 1.

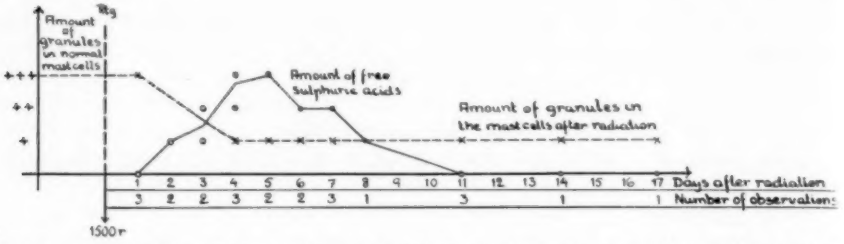
Rtg
Amount of granules in normal mast cells
+++
++
+
Amount of free Sulphuric acids
Amount of granules in the mast cells after radiation
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 Days after radiation
3 2 2 3 2 2 3 1 3 1 1 Number of observations
1500r

Fig. 1. In this figure the results of a series of observations at different times after roentgen treatment (1,500 *r*) are plotted. To the left of the vertical dotted line the normal amount of granules in the mast cells is marked +++. The fig. shows the occurrence and approximate amount of free sulphuric acids, together with the decreased quantities of granules in the mast cells (+). — The corresponding curves for the radium material are of the same type.

(2) At the same time and in the same treated skin areas a great many of the granules of the mast cells had disappeared (Fig. 1). A greater number of mast cells containing only a few granules were seen.

(3) No positive increase or decrease in the number of large mast cells in the subcutaneous connective tissue could be observed. Yet there seemed to be a decrease in the number of small mast cells in the corium.

(4) To judge from WEIGERT's elastic tissue staining, neither an increase nor a decrease in the number of elastic fibres was observed.

Those changes in the microscopical picture of the connective tissue were not complicated by the appearance of any considerable amount of inflammatory wandering cells.

In the author's opinion, these results indicate that some of the sulphuric acids in the granules of the mast cells leave the cytoplasm of the mast cells, and spread diffusely over the surrounding connective tissue after exposure to roentgen rays.

On the changes after treatment with γ-rays. The results were *all of the same nature but* were *much more pronounced after γ-ray treatment as after roentgen treatment.*

Yet there were some characteristic differences as regards the time of appearance of the diffusely distributed methachromatical substances. After exposure to γ-rays, those substances appeared already a few hours after exposure.

As mentioned above, three different doses were given. In comparison with Fig. 1, the corresponding curve for the group of animals that received

the smallest γ-ray dose (1,050 *r*), had a similar course. On the other hand, the corresponding curves for higher doses of γ-rays (1,575 *r* and 2,100 *r*) showed a more irregular course, particularly for the largest dose. This seems to depend on the inflammatory reactions in epidermis and the subjacent connective tissue, which make the interpretation of the microscopic picture more difficult. In view of those inflammatory complications a larger material must be studied before exact results are obtained.

The author's results indicate that sulphuric acids with high molecular weight are set free from the mast cells to the subcutaneous connective tissue after exposure to γ-rays.

Discussion of Results

The preliminary results of this research seem to indicate that after roentgen and gamma radiation, given in one-time doses, one gets a liberation of sulphuric acids from the granules of the mast cells. The free sulphuric acids spread diffusely over the surrounding connective tissue.

This process begins a very short time after radiation and then is one of the very earliest microscopic changes in the radiated skin.

The threshold dosage for the onset of this process has not yet been determined, nor the ultimate fate of the radiated mast cells.

To judge from the experiments described above, the threshold dose seems to be smaller than 1,000 *r* both for roentgen and γ-rays. — As regards the final fate of radiated mast cells, no definite statement can yet be made from the experiments. Yet the preliminary results after both roentgen and radium treatment showed that the number of small mast cells in the corium decreased, and if we take into consideration the results of the original observations on radiated human tumor tissue (mentioned in Introduction), which showed a heavy decrease in the number of mast cells, the final fate of radiated mast cells seems to be their disappearance and destruction. These questions will be further studied on a larger material.

As to the reason why the mast cells lose their sulphuric acids different explanations could be considered. We have to bear in mind either damage to the mast cells or changes in the surrounding connective tissue, which changes might cause a liberation of sulphuric acids from the mast cells.

SUMMARY

A preliminary report has been made on the changes of the mast cells in the connective tissue of the skin after roentgen and γ-ray treatment. The results seem to indicate that, very soon after the radiation, some of the sulphuric acids in the granules of the mast cells leave the cytoplasm of the mast cells and spread diffusely in the surrounding connective tissue.

ZUSAMMENFASSUNG

Verf. berichtet in einer vorläufigen Mitteilung über Veränderungen, welche an den Mastzellen des Unterhautbindegewebes nach Röntgen- wie auch nach Gammabestrahlung beobachtet worden sind. Die Untersuchungen machen es wahrscheinlich, dass die Mastzellen kurze Zeit nach der Bestrahlung Esterschwefelsäuren an das umgebende Bindegewebe abgeben.

RÉSUMÉ

L'auteur donne une communication préliminaire des altérations des mastocytes du tissu conjonctif de la peau après le traitement du Roentgen et du Radium. Les résultats montrent que les mastocytes donnent, peu après la radiation, des esthers des acides sulfuriques au tissu conjonctif de l'entourage.

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FROM THE PHYSICS DEPARTMENT OF KING GUSTAF V. JUBILEE CLINIC, STOCKHOLM
(CHIEF: R. M. SIEVERT)

SOME EXPERIMENTS IN IRRADIATING DROSOPHILA EGGS WITH ROENTGEN-RAYS AND γ-RAYS IN A MAGNETIC FIELD[1]

by

Arne Forssberg

The idea of increasing the effect on the living organism of roentgen- and γ-radiation by the simultaneous influence of an agent of some other kind is not new. SCOTT's (1) monograph on the biological effects of radiation contains a summary of these and allied problems. The influence of temperature changes during, before and after radiation has in the first place been investigated. Other experiments have included the effects of various chemical agents, principally narcotics, and the injection of heavy metal salts with a view to increase the local effect of the secondary radiation round the place of the injection. The experimental investigation described in this paper was undertaken to test whether the biological effect of radiation will be changed if a strong magnetic field is applied on the biological object during the experiment. Eggs of *Drosophila melanogaster* were used for the experiments, and the mortality rate at a dose of 165 r, which ordinarily is about 50 %, was determined as a criterion of the effect.

Before giving an account of the experiments, it will be expedient to try to ascertain whether any demonstrable biological effects may be expected from a magnetic field as such. This question has been dealt with in papers by LENGYEL (2) and DELORENZI (3) who found cytological changes in tissue cultures, both in the form of an increased number of mitoses (LENGYEL states that these increased at the rate of 16.5 : 9.6, which is a fairly considerable effect), and in the form of cytological anomalies such as irregular cell division, agglomerations of chromatin, and microscopically observable streaks in the plasma. KIMBALL (4) reports a retarding effect on the budding of yeast from the field of a small magnet,

[1] Submitted for publication Nov. 24, 1939.

while JENNISON (5) with a stronger magnet was not able to find any effect upon the growth of various microorganisms. Provided that these positive observations, which as far as I know are rather isolated, are correct, they indicate the possibility of the effects of roentgen-radiation and a magnetic field being additive. It was therefore necessary first to ascertain if a magnetic field of the strength obtainable with the apparatus at our disposal had any measurable effect on the development of *Drosophila* eggs, e. g. made any difference to their hatching ratio or to their time of development from new-laid eggs to fully developed flies.

A physical explanation of an observed change in the biological effect is, on the other hand, conceivable if the object is situated in a strong magnetic field during the irradiation. According to current opinion on the subject, the biological effects of the short-wave rays are due to the appearance of secondary electrons in the irradiated tissue and to the effects transmitted by them to the molecules of that tissue. The electron paths in the tissue, and perhaps also the paths of the ions formed, might conceivably be changed by the application of a sufficiently strong magnetic field during the irradiation, which — at least theoretically — might produce another ultimate biological effect. The direction of molecules of magnetic moment might also become more or less parallel to the field, which may conceivably be of some biological significance.

It is difficult to decide in which of these alternatives the explanation of the effect observed should be sought.

Below, the experimental apparatus will first be described. As regards cultures, and the technique in experiments on *Drosophila*, I merely refer to a previous paper (6).

The Electromagnet: The magnetic field was obtained from an electromagnet designed for other purposes by BENNER (7) and altered for this work, giving at a maximum current of about 15 amp. a field strength of 6,000 Gauss. The magnet poles were vertical and hollow, allowing the circulation of cooling water. Overheating of the iron parts was thus avoided, and the temperature during the experiment could be kept constant within $\pm 0.1°$. An air gap was provided between the poles, 1 cm. high and 2 cm. in diameter, in which the eggs were placed during the radiation. To avoid the secondary electron radiation emitted from adjacent metal parts and drawn into the field, the eggs were placed in celluloid cups, the insides of which were covered by a 3 mm. layer of paraffin to absorb the penetrating electron radiation. The agar clots were placed in these cups with the eggs facing the rays, the cups were filled with physiological saline solution and covered by a celluloid lid and 3 mm. of paraffin. These arrangements will make the conditions of the secondary radiation at the surface of the eggs correspond as closely as possible to those obtained within the cell.

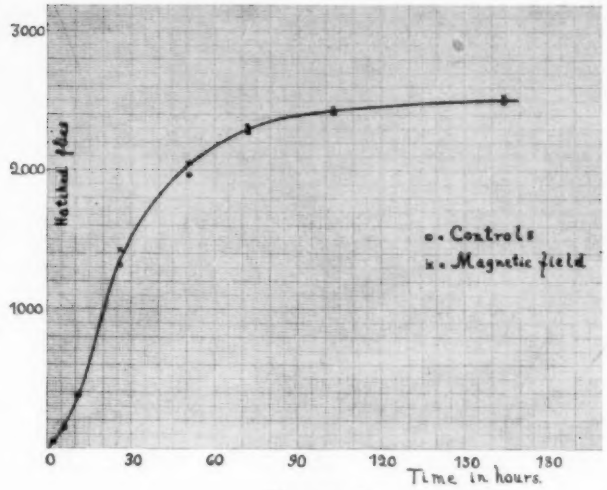

Diagram I

The direction of the magnetic field could be rapidly changed in the course of the experiment by means of a special switch, consisting of tilting mercury tubes on a motor-driven cam-shaft. The experiment could thus be made either in a constant magnetic field, or in one where the poles were reversed approximately every five seconds.

An iron frame-work of the same shape and dimensions as the poles of the electro-magnet was placed beside these in the beam from the roentgen-ray tube. Several observations were taken to check that the radiation intensity was the same between the magnet poles and at the corresponding point of the control model. The averages of 5 observations with a condenser chamber (8) gave values differing by only 0.1 to 0.2 r. An iron screen protected the control model from the magnet, to prevent any magnetic field from arising there. The celluloid cups containing the eggs were thus exposed exactly as much to both primary and secondary radiation in the magnetic field as in the control model.

Three different intensities, viz. 7.5, 24 and 66 r/min., were used in the experiments, and in all of them the dose was 165 r.

Other conditions were: Müller Metwa Metalix tube, fed from a Stabilivolt apparatus; 150 kV, 4 mA, unfiltered radiation. In some cases γ-radiation was used, in an arrangement described on page 218.

The experiments were carried out in stages as follows:

A. New-laid *Drosophila* eggs were placed in the magnetic field, without any irradiation, for 60 min., and then transferred to a thermostat

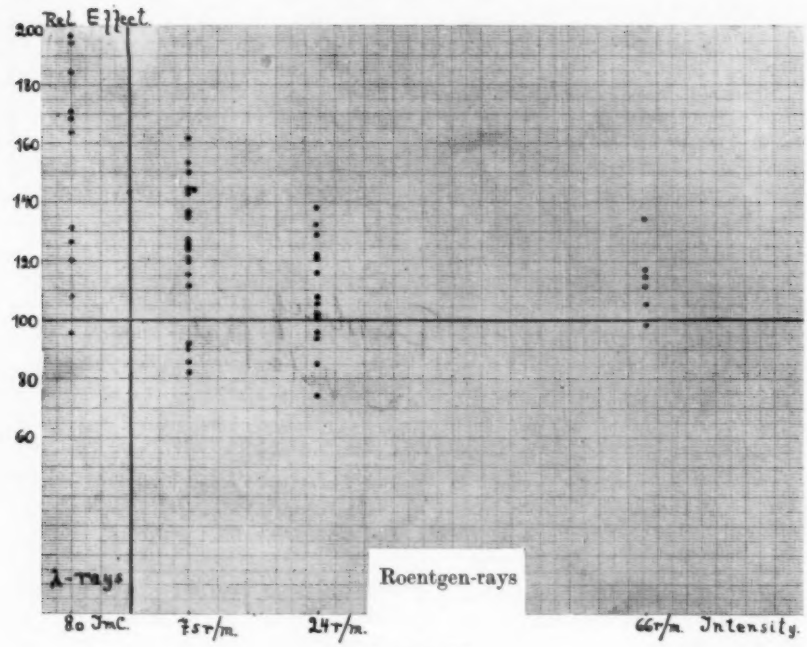

Diagram II

at 23° with an equal number of controls; the hatching ratio and the time of development to completely hatched flies were then determined.

B. Eggs placed in the magnetic field and in the control model were simultaneously irradiated in a series of experiments without the magnet being excited; this was done in order to obtain a biological check that the intensity was the same in both cases.

C. The principal experiments were carried out a) in a constant magnetic field, and b) with rapid reversals of the magnet poles. As no difference could be observed between the constant and the variable field, the results have been pooled in the following description.

Results of the Experiments: A. A total of 5,300 eggs and as many controls were used in 14 experiments, with an approximately equal number of eggs in the magnetic field and of controls in each. The ratio of hatched eggs was 95.8 ± 2.4 % in the magnetic experiments, and 94.3 ± 2.1 % among the controls, i. e. there was no demonstrable difference between eggs treated in the magnetic field and the control eggs.

The larvæ were then allowed to develop into flies, and the period of development was determined by counting the newly-hatched flies at

ntervals of some hours until all were hatched. The results are given n diagram I, in which the time 0 signifies the time when the first lies were hatched. As seen in the diagram, all the points — whether eferring to eggs treated in the magnetic field or to controls — are airly even distributed along the same time curve, especially if allowance s made or different hatching ratios (95.8 % in the magnetic field, ontrols = 94.3 %).

Even though some cytological changes may have been produced by he influence of the magnetic field, these were obviously under these xperimental conditions of neither the nature nor the strength to affect he mortality rates and time of development of the eggs.

B. The object of the second series was to obtain also a biological check that the effective dose was the same in the magnetic field and in the control model. Ten experimental series with more than 2,000 eggs were made while both the magnet and the control model were irradiated, but without any field current being switched on. Mortality rates of 54.5 ± 6.1 % and 52.0 ± 5.7 % respectively were obtained. These figures, and the physical measurement of the radiation described above, indicate that the doses given between the magnetic poles and in the control model were the same.

C. The results of the experiments with roentgen- and γ-radiation in a magnetic field have been plotted in Diagram II. Thirty-nine roentgen-ray and eleven γ-ray experiments were made. In every case the dose was 165 r. The intensity of the radiation was used as abscissa. The ordinate values are plotted from the formula:

$$\frac{\% \text{ of dead in the magnetic field}}{\% \text{ of dead in the control model}} \times 100$$

i. e., the relative difference in per cent between the results in the magnetic and in the control fields. Values above 100 thus indicate that the mortality was higher under radiation in the magnetic field, and values below 100 that it was less. In the right part of the diagram are given the values obtained with roentgen-radiation, and in the left those obtained with γ-radiation from two equal 50 mg. preparations, with filters of 0.30 mm. Au + 0.35 mm. Pt. One of the latter was during the experiments placed 2.5 cm. from the culture in the magnetic field, the other the same distance from the control culture. The time of radiation was selected to give a dose of 165 r here, too, on the assumption that with the said filter an intensity = 7.5 r per hour was obtained 1 cm. from 1 mg. of radium. As very long radiation times — about 3 hours — are necessary to obtain any biological effect from γ-radiation, and as it would be impossible to keep the eggs in a physiological NaCl-solution for so long time without

injuriously affecting the normal hatching ratio, these experiments had to be carried out without immersing the eggs in liquid. The secondary radiation conditions were thus different from those in the roentgen-ray experiments, and the hard β-radiation from the metal parts may conceivably have been drawn into the field and thus have reinforced the biological effect. The γ-ray experiments are therefore not included in the following calculations. The diagram shows, however, that the values conform well to those obtained in the roentgen-ray experiments. The intensity is given in Imc (1 Imc = the intensity 1 cm. from a punctiform preparation of 1 mg. Ra filtered through 0.5 mm. Pt).

Two different statistical methods may be used for the study of the results. The diagram shows that out of 39 experiments 30 resulted in a higher mortality rate in the magnetic field, while in the remaining 9 the mortality rate was higher in the control field. If the distribution were a random one, the probability of values above and below 100 ought to be the same, and in this case one may therefore ask what the chances are that the distribution of 30 : 9 is fortuitous. The binomial theorem gives the formula:

$$\frac{39!}{30! \cdot 9!} \cdot \left(\frac{1}{2}\right)^{39} \cdot \left(1 + \frac{9}{31} + \frac{9 \cdot 8}{31 \cdot 32} + \ldots\right) = \frac{1}{1890}$$

i. e., the odds are 1890 to 1 against 30 or more experiments giving a value above 100. It is consequently fairly certain that the magnetic field has to some extent influenced the radiation in these experiments. According to the other statistical method, we calculate the average of all experiments and of their mean errors, which gives a value of 116.8 ± 3.4. This would mean that the average mortality rate during radiation was 16.8 % higher in the magnetic field than in the control model. As that difference is about five times larger than the mean error, this method, too, may entitle us to consider a small influence of the magnetic field proved.

At low intensities (with consequently longer periods of radiation and longer influences from the magnet field) the effect seems to be higher, but the experimental material, especially at I = 66 r/min. is so scanty that a discussion of this eventuality does not seem warranted.

The above can thus be summarized as follows:

If *Drosophila* eggs are exposed to roentgen-radiation in a strong magnetic field, the effect of the radiation will be strengthened. This cannot be due to variations of temperature, for accurate control observations indicated that these never exceeded 0.2°. Nor can the cause be sought in β-radiation from surrounding metal parts. We are therefore restricted to one of the following explanations.

1) The possibility of a summation of separate injurious influences from the magnetic field and the roentgen-radiation. Although the preliminary experiments indicated that the hatching ratio and the time of development were normal for eggs exposed to a magnetic field but not to radiation, the possibility of cytological changes which only became apparent in connection with injuries due to the radiation must not be disregarded.

2) The paths of the secondary electrons released in the eggs and immediately around them (in the physiological salt solution) are altered in the field. At the tube voltage used, these secondary electrons have a maximum range of about 0.2 mm. in water, the majority of them much less. At that velocity, their paths will in a field of 6,000 Gauss have a radius of curvature of about 2 mm. These electrons will thus only describe an arc of about 6°, which is very near to a straight line. It is true that the paths of the slower electrons will have a smaller radius of curvature, but their free range will diminish even more, and it is therefore difficult to see how these circumstances can be of any biological significance. The maximum range of β-rays is also shorter than their radius of curvature.

3) The ionizing effect of roentgen-rays and γ-rays on the molecules of the organism will also cause ions to form, which owing to their movement and electric charge will be affected by the magnetic field. This may interfere in the secondary chemical reactions accompanying the primary ionization. The magnetic moment of the ions may also conceivably be of some importance.

4) If molecules in the tissues have a magnetic moment and their direction is influenced by the magnetic field, this might have some influence on the biological effect, the rays in my experiments always coming from a direction at right angles to the field.

It does not seem possible to decide, on the basis of these experiments, which of the above explanations best covers the experimental facts. Nevertheless the author thought it worth while to publish these results.

ZUSAMMENFASSUNG

Der Verfasser beschreibt eine Anordnung für die Bestrahlung von Drosophilaeiern mit Röntgen- und γ-Strahlung unter gleichzeitigem Anbringen eines magnetischen Feldes von 6,000 Gauss.

Die Resultate zeigen eine kleine Zunahme des Strahlungseffekts bei gleichzeitiger Applikation des Magnetfeldes. Nach Ausschliessung einiger möglicher Erklärungen hierzu werden die folgenden alternativen Hypothesen diskutiert.

Eine einfache Summierung von dem Strahlenschaden und eine eventuelle schädliche Einwirkung von dem Magnetfeld ist geschehen.

Die Bahnen der Sekundärelektronen sind geändert geworden.

Die Bahnen der von Röntgen- und γ-Strahlung jonisierten Moleküle können eventuell durch das Magnetfeld beeinflusst werden.

Die Moleküle der Zelle haben ein magnetisches Moment und indem sie in einer Ebene senkrecht gegen die Strahlungsrichtung orientiert sind, könnte vielleicht ein veränderter Strahlungseffekt entstehen.

Der Verfasser erwähnt die Schwierigkeit, einen definitiven Standpunkt in der Wahl zwischen diesen Alternativen einzunehmen.

SUMMARY

The author describes an arrangement for the irradiation of Drosophila eggs with roentgen- and γ-rays during a simultaneous application of a magnetic field of 6,000 Gauss.

The results show a small increase of the radiation effect at a simultaneous application of the magnetic field. After elimination of some possible explanations the following alternative hypotheses are discussed.

A simple summation of the radiation damage and a possible injurious influence of the magnetic field has occurred.

The paths of the secondary electrons in the field have changed.

The paths of the molecules ionized by the roentgen- and γ-radiation may possibly be influenced by the field.

The molecules of the cell have a magnetic moment, and through their getting in a plane perpendicular to the radiation direction a changed radiation effect might be brought about.

The author points out the difficulty of taking up a definitive position with reference to these alternatives, on the basis of the above experiments.

RÉSUMÉ

L'auteur décrit un arrangement pour irradier les œufs de Drosophila avec les rayons roentgen et γ pendant l'application simultanée d'un champ magnétique de 6,000 Gauss.

Les résultats indiquent une petite augmentation de l'effet de la radiation en appliquant simultanément le champ magnétique. Après exclusion de quelques explications possibles les hypothèses alternatives suivantes sont discutées.

Les dommages de la radiation et l'influence nuisible éventuelle du champ magnétique se sont simplement additionnés.

Les traces des électrons secondaires dans le champ ont changé.

Les traces des molécules ionisées par les radiations roentgen et γ peuvent éventuellement être influencées par le champ magnétique.

Les molécules de la cellule ont un moment magnétique, et leur orientation dans un plan perpendiculaire à la direction de la radiation pourrait peut-être changer l'effet de la radiation.

L'auteur attire l'attention sur la difficulté de faire le choix entre ces alternatives.

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FROM THE RADIUM CENTRE, COPENHAGEN, DENMARK (CHIEF: JENS NIELSEN, M. D.)

BONE DESTRUCTION IN CARCINOMA OF THE UTERINE CERVIX, BY DIRECT PROPAGATION OR BY LYMPHOGENIC OR HEMATOGENIC METASTASIS[1]

by

Flemming Nørgaard

The search for metastases and recurrences, and the determination of their distribution, are essential parts of the treatment of malignant tumors; and, as in many other disease groups, roentgen examination has here become one of our commonest, most indispensable aids. In several malignant tumors, such as carcinomata of the breast and the prostate, hypernephroma and Ewing's sarcoma, the metastases are even particularly characteristic radio-clinically, both in appearance, distribution, development before treatment, and in their reaction to roentgen irradiation. In those forms of cancer, radiography has undoubtedly added important features to the pathological picture of the condition, and is therefore considered a matter of course, as part of the clinical examination. In cervical cancer, roentgen examination for metastases has not been used hitherto as routine procedure, either in Denmark or — so far as may be gathered from the literature — in many institutions elsewhere. And yet it was shown already in 1933, by PHILIPP and SCHAEFER, that such examination, where the case permits, may furnish highly valuable information, which could not be obtained even by the most careful ordinary clinical inspection, in spite of the ready accessibility of the organs here involved, to observation and palpation.

At the Radium Centre in Copenhagen, where about 300 new cases of cervical cancer are received yearly, and frequent after-examinations are constantly made of numerous patients already treated, examination of the bone system, specially of the lumbar spine and the pelvis, has in the

[1] Read at the meeting of the Northern Association for Medical Radiology, Oslo, June 1939. Submitted for publication Oct. 2, 1939.

last year been undertaken in a limited number of these cases. Following is a brief description of the changes observed, and a discussion of their bearing on the estimate to be formed of the condition of the individual patient, and the possibility of their treatment.

The lesions consist almost exclusively in destructions of bone. More rarely there is also sclerosis, probably as expression for the bone's reaction against the attack of the new-growth. Nearly always the changes occur as the result of direct invasion of the bone from adjoining, cancerously infiltrated tissue. Such invasion may take place at any point where the infiltration extends so far that contact is established with the osseous tissue; but as the propagation or recurrence of a cervical cancer is almost invariably either to the parametria or to the lymph nodes along the vessels of the pelvis, i. e. to the iliac vessels and the abdominal aorta, the lesions likewise fall into two well defined, characteristic main groups. Where the propagation or recurrence is to the parametria we should after this expect to find the earliest signs of arrosion at the latter's attachment to the pelvic wall; but whether because incipient lesions at those points are not readily brought out by the roentgen examination, or because the fleshy padding there offers a certain protection to the bone, the first change is, at least in our material, seen along the iliopectineal line, in the typical form of a flat, irregular erosion extending for a few centimeters and usually localised to the posterior half of the bone; besides which there is sometimes a certain amount of circumferential sclerosis (Fig. 1). In more advanced cases the iliopectineal line is quite blurred, ragged and eroded all the way from the sacroiliac articulation to the pectineal line of the pubis; and upwards on the inner side of the ala ilii there are, besides, rarefactions, large or small, often sharply circumscribed, and possibly due to arrosion directly at the attachment of the parametria (Fig. 2). Thence the infiltration seems to proceed most often through, or back of the bone, across the ischial spine, where the destructions are projected in over the acetabulum, and the lesions may become so great that large portions of the pelvic half involved are almost obliterated. Fig. 3 shows such a case. When the examination took place, the patient had not been a bed-case. She had pain across the loin when walking, but not when lying down resting. Exploration revealed cicatricial changes, but no recurrence could be demonstrated. The pelvic contour felt alike on both sides, but there was tenderness to percussion over the right iliac crest.

Rather more important than the demonstration of these severe lesions is, however, the recognition of the faint, earliest changes. As suspicious indication of such should, according to our experience, be interpreted, first of all, any, even the slightest, rarefaction along the normally extremely compact and sharply defined iliopectineal line; and at

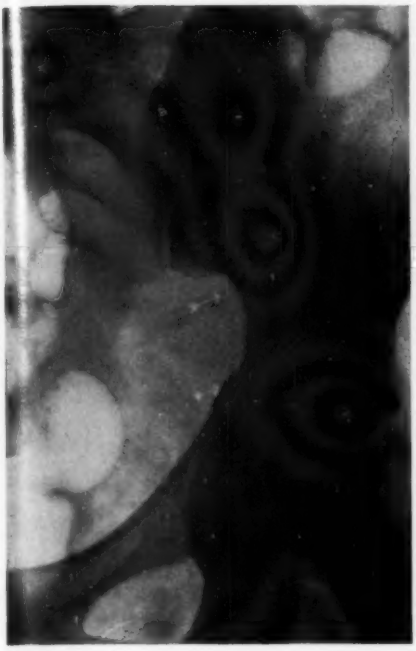

Fig. 1.

Fig. 2.

the same time it should be in mind to see whether any soft-tissue shadow corresponding to such rarefaction can be demonstrated. In several cases, repeated examinations have enabled us to follow the development from such barely perceptible changes — too slight to be shown in illustrations — to typical destructions of the bone.

Also in the other main group of cases, where the propagation is to the regional lymph nodes along the iliac vessels and the abdominal aorta, or where recurrence sets in there, the bone may become involved through simple, direct invasion from the adjoining tumor tissue. Like PHILIPP and SCHAEFER, we have been able positively to ascertain by autopsies that the invasion occurred directly from the lymph nodes, and not through hematogenic metastasis. In such cases the sections of bone involved are the ala sacralis, the portions of the iliac bone nearest to the sacroiliac articulation, and the lumbar vertebrae. In the two first named localities, the lesions appear in the form of rarefactions, in the lumbar vertebræ they show as destructions on the lateral aspects of the vertebral bodies, usually unilateral, and oftenest in the third and fourth vertebræ.

Fig. 3.

Also in cases of this group the lesions can become enormous, with extensive destruction of several vertebræ. In one case, such destruction ended in total collapse of the third lumbar vertebra, resulting in complete paraplegia of the lower extremities.

Also in regard to these bone destructions it is, of course, the demonstration of the incipient changes that is of greatest interest. According to PHILIPP and SCHAEFER a typical early change, as reflected in the radiologic picture, consists in the articular processes on the affected side being seen more distinctly than those on the sound side, owing to loss of substance in the bodies of the vertebræ, by which they are usually obscured. Here, too, a characteristic soft-tissue shadow may often help to an early diagnosis, as the intumescence of the lymph nodes will sometimes show as a distinct outbulging of the psoas shadow on the same side. An example of this is seen in Fig. 4, which also shows an

incipient destruction of the left side of the body of the third lumbar vertebra.

Hematogenic distant metastases of cervical cancer to bone are uncommon. In the course of fourteen or fifteen years we have met with only 5 cases, curiously enough all located to bones of the lower extremities; namely, 2 to femora, 2 to tibiæ and 1 to tarsus. One of them is noteworthy by the fact that it has apparently been cured by roentgen treatment, the patient being alive and free from symptoms after nearly five years.

While the hematogenic metastases thus present no particular interest apart from their rarity, the changes described as typical for the two main groups are undoubtedly important from the everyday clinical point of view, not least on account of their characteristic localisation to a limited number of sites. They do not in themselves produce any actual symptoms except the tenderness to percussion, and neither this nor tenderness from walking or other movements are constant features. There *can* be total absence of actual pain, and in cases where pain exists it may very well be due to a concomitant affection of the lumbosacral plexus. As the lesions are radiologically demonstrable, they form a good objective basis for evaluation of the spread of a tumour from one examination to the next in cases where the existence of the malignant growth has already been definitely established; but the greatest importance of their demonstration, by far, is in the cases where it has not been possible either by exploration, palpation or other clinical means to demonstrate propagation beyond the local, primary growth, or to ascertain a recurrence suspected from the symptoms. From operations and autopsies we know cases where there is a small primary tumor and at the same time large, high glandular metastases, which the gynecological examination has failed to disclose; and it has often enough been remarked how extremely difficult, or even impossible, it can sometimes be, even for the practiced and experienced clinician, to determine if a recurrence has taken place, and that in such circumstances only the subsequent course will tell whether this is the case or not. It is therefore all the more important that *all* available aids to diagnosis should be made use of, roentgen examinations like the ones here described as well as, for instance, cystoscopy, urography and neurological examination. I may add that even in cases of rather extensive destructions the blood precipitation reaction may be quite normal; thus, in one case with typical destructions of vertebræ two separate determinations gave precipitation reactions of respectively 5 and 9 mm./h.

As will be understood from the foregoing, we have in several difficult cases found these roentgen examinations extremely helpful. Following is a brief report of yet a couple of characteristic examples.

Woman, aged 56 years, who had been treated by local radium eleven years ago for 1st to 2nd grade cancer of the uterine cervix, and who in the intervening years had remained absolutely free from symptoms, began to suffer from pain in the region of the left hip. Exploration failed to reveal any signs of recurrence; there was some tenderness to palpation over the left side of the pelvis. *The roentgen examination disclosed typical destruction of the left ala sacralis.*

Woman, aged 50 years, formerly treated by radium for 1st grade cervical cancer, and since then symptomfree for eighteen months, was referred by medica. dep't to be roentgen-treated for roentgen-diagnosed spondylitis deformans. Exploration showed no signs of cancer recurrence. *Roentgen examination of the pelvis disclosed typical destruction on the iliopectineal line.*

Woman, aged 35 years, treated by combined radium and roentgen for 1st grade cervical cancer, was after ended treatment transferred from the Radium Centre to sanatorium for neuropathics, owing to depression. During her stay there she suffered from pain in the lower extremities, specially in the left. Large doses of vitamin-B proved ineffective. Returned to the Radium Centre six months after her discharge from there. Clinical examination as well as repeated gynecological examinations (also under narcosis) failed to reveal any recurrence; also roentgen examination of the pelvis was negative. The patient showed marked signs of functional disorder, but as her complaints were very persistent, *another roentgen examination was made six weeks later, and typical destruction on the iliopectineal line was found.* Repeated gynecological examination still failed to show any recurrence. She died of uremia six months later, in another hospital.

These lesions are by no means uncommon. In the course of about 8 months we have demonstrated them in 19 patients. In two of these both the pelvis and the spine were involved, in the rest the lesions were equally divided between the two locations. They were demonstrated in one fourth to one fifth of all the patients examined by roentgen, but of their absolute incidence nothing can be said on the basis of our material, because the examinations were made on selected cases. Of the 19 patients 4 have died; on 3 of these autopsy was performed, which confirmed the roentgen findings.

The osseus changes described here, which are thus due to invasion of tumor tissue, must not be confounded with the lesions of the neck of the femur, of which some cases have been reported from several French and German clinics (BACLESSE, BAENSCH, KROPP, PHILIPP, SCHIFFBAUEMER et al.), which are due to irradiation with roentgen-ray or radium, and give rise to spontaneous fractures and pseudarthroses. Such cases have not been observed among our patients, no doubt because we employ a different technic of treatment. That in our cases it is not a question of such ray lesions is proved both by the findings in the cases where autopsy was performed and by the fact that characteristic destructions have been observed both by PHILIPP and by TRAUBE in patients operated upon and not subjected to radiation treatment. Besides, we have ourselves observed pelvic destructions in another, entirely untreated case (Fig. 5).

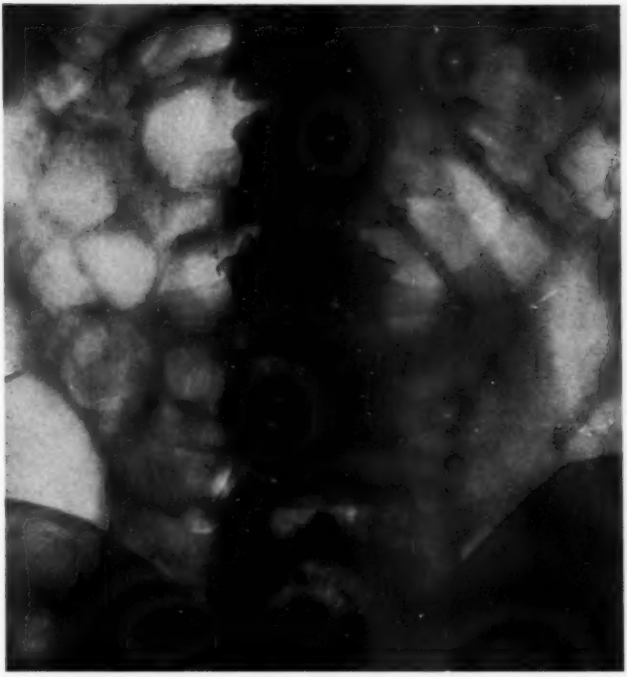

Fig. 4.

This patient was a woman, aged 59 years, with a cervical cancer of the 3rd grade, in whom roentgen examination at the time when the treatment was instituted showed extensive destruction on the iliopectineal line and projecting into the iliac bone and the ischium. The examination can thus in some cases be of value also as a means to correct grading of the cancer.

In many of the cases a palliative or pain-stilling effect can be obtained by the application of moderate roentgen doses, generally of 2,000 to 4,000 *r*, distributed to two or four fields, and, if necessary, repeated. Beyond this, PHILIPP believed that practically nothing could be done for these patients; yet we have in some cases seen an indubitable, though in the severe ones probably only temporary, arrest of the destructive processes, as the result of more intensive roentgen treatment. And in one case, that of the patient just mentioned, in whom bone destruction was discovered at the time when the treatment was first instituted, and who was given protracted, fractioned irradiation until strong cutaneous reaction

Fig. 5.

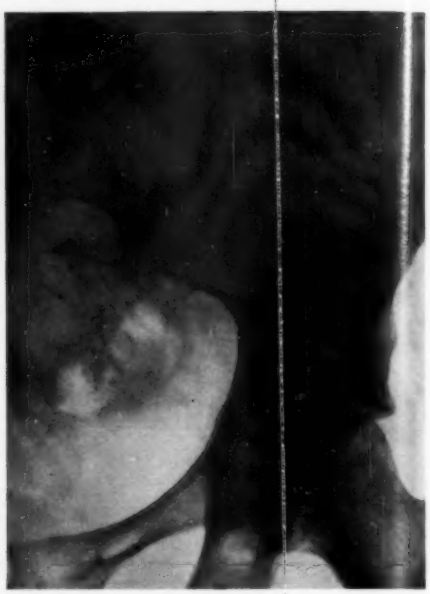

Fig. 6.

(8,400 *r* to 6 fields of 10 × 15 cm.; 180 kV; distance, 40 cm.; 3 mm. Al. + 0.5 mm. Cu.), the destructions are now, a year after, repaired to such an extent (Fig. 6) that we may begin to have hope of a more lasting, both subjective and objective improvement. If it should be found that such an improvement can actually be obtained, the value of the demonstration of these changes will be immensely enhanced; and this applies, of course, primarily to the *early* changes, to which I have particularly wished to call attention here.

SUMMARY

As first shown by PHILIPP and SCHAEFER, typical osseous destructions in cervical cancer may occur at any point where the tumor tissue comes into contact with bone, either as the result of direct propagation or by invasion from metastases in the regional lymph nodes. Corresponding to these two manners of origin, the osseous changes, from their location, fall into two main groups. Hematogenic metastases to bone, on the other hand, are uncommon. In this paper, the author specially discusses the earliest changes demonstrable by roentgen examination, and emphasises the value of this examination, which has perhaps not been sufficiently realised hitherto.

ZUSAMMENFASSUNG

Wie PHILIPP und SCHAEFER zuerst gezeigt haben, können durch Zervixkarzinom typische Knochenzerstörungen an jedem Punkte entstehen, wo das Tumorgewebe mit Knochen in Berührung kommt, entweder durch direkte Ausbreitung oder durch Metastaseneinwanderung in die regionären Lymphknoten. Entsprechend diesen zwei Ursprungsarten teilen sich die Knochenveränderungen nach ihrer Lokalisation in zwei Hauptgruppen. Anderseits sind hämatogene Knochenveränderungen ungewöhnlich. In dieser Arbeit erörtert Verf. besonders die frühest durch Röntgenuntersuchung nachweisbaren Veränderungen und betont nachdrücklich den Wert dieser Untersuchung, der bisher vielleicht nicht genügend erkannt worden ist.

RÉSUMÉ

Comme PHILIPP et SCHAEFER ont été les premiers à le montrer une destruction osseuse typique apparaît dans le cancer du col à chaque endroit où le tissu de la tumeur se trouve en contact avec l'os, soit par la propagation directe soit par l'invasion des métastases dans les ganglions lymphatiques régionaux. Correspondant à ces deux origines les altérations osseuses se divisent en deux groupes principaux du point de vue de leur localisation. Les métastases hématogènes des os sont rares. Dans cet article l'auteur discute spécialement les toutes premières altérations qui peuvent être décelées par l'examen radiologique et il vante la valeur de cet examen, qui n'est peut-être pas encore assez apprécié.

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